

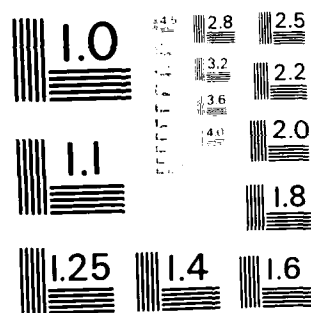
AD-A131 121 TECHNICAL FEASIBILITY STUDY OF NAVY PIER CONCEPTS  
CONCEPT 1 THE EXPEDITIONARY PIER(U) LIN (T Y)  
INTERNATIONAL SAN FRANCISCO CA JAN 83

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UNCLASSIFIED NAVY PIER CONCEPTS-1/83 N00014-80-C-0889 F/G 13/2

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NAVY PIER CONCEPTS  
REPORT No. 1/83

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THE  
EXPEDITIONARY  
PIER

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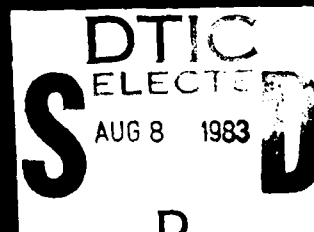
■ DEPARTMENT OF THE NAVY

OFFICE OF NAVAL RESEARCH  
ARLINGTON, VIRGINIA

SUBMITTED BY:

■ T.Y. LIN INTERNATIONAL

JANUARY 1983



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The expeditionary pier was developed to provide Navy and Marine Corps expeditionary forces operating overseas with the immediate use of full-service piers. These piers can accommodate from four to six ships and have provision for all the services expected from a permanent pier. Present design problems are limited to consideration of the hinge joint and anchoring system. The cost of expeditionary piers would be higher than traditional waterfront construction, but their ability to move with the Fleet is a great benefit.		

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## **TECHNICAL FEASIBILITY STUDY OF PIER CONCEPTS**

### **1. INTRODUCTION**

The Navy pier concept study contract for the year 1982/83 called for the continuing development of three selected pier concepts to the point that their feasibility vis-a-vis the state-of-the-art technology may be assessed, and their deficiencies and problem areas identified. The three concepts selected for this study are:

- Concept 1 - **The Expeditionary Pier**
- Concept 2 - **The Floating Marina Pier**
- Concept 3 - **The Mobile Underwater Submarine Base**

Each concept will take up about one third of the contract year that began in September 1982. The results of the year's work will also be presented in a second paper to an engineering conference in or out of the USA.

This report addresses the technical feasibility of the first concept, i.e., the expeditionary pier, and is organized to cover the various study areas as follows:

- a. Investigation of the general validity of the design, and the parameters used in the development of the concept. Loading conditions, pier dimensions, structural sizes, flotation characteristics, etc. that were assumed for the original concept will be verified by more detailed analysis and designs during this investigation.
- b. Investigation of analytical and design feasibility: The purpose is to determine the adequacy of the state-of-the-art (SOA) technology in carrying out the analysis and the design of expeditionary piers.
- c. Investigation of constructional feasibility. Current construction methods that could be used in building the pier will be surveyed and assessed.
- d. Investigation and identification of problem areas and technological deficiencies. This will be assessed in relation to their influence and impact on the development of the pier.

### **2. THE EXPEDITIONARY PIER**

To recap, the expeditionary pier was developed to provide the naval expeditionary force operating overseas the immediate use of a full-service pier. To be effective, it should be large enough to accommodate at least four, preferably six, destroyer class vessels. For these purposes, the pier must be self-sufficient, of sufficient size to berth four to six ships, relocatable and rapidly deployable. These features will be discussed below.

## **2.1 Self-Sufficiency**

Self-sufficiency means the pier is equipped to provide full berthing services to navy ships and, if necessary, to enable them to go "cold iron." In addition, it will also carry sufficient quantities of supplies to replenish the ships for long periods of time, perform minor repairs, and provide recreational and training facilities for the ship's crew.

## **2.2 Berthing Capacity**

The berthing capacity of the pier is determined by the size of the ships, the configuration and the size of the pier. Originally, the pier was designed for the future Navy ships, which were conceived to be small, fast and powerful vessels that are produced in sufficiently large numbers to achieve the effect of deterrence. Since the present destroyer class Navy ships are not much longer than the assumed future ship, the pier should provide the same number of berths for the present ships, if it is intended to be used in the near future. As shown, the berthing capacity of the pier for the various schemes is as follows:

Scheme A: Six big ships (destroyer class) and a number of smaller crafts along the central section of the spine pier.

Scheme B: Same as Scheme A

Scheme C: Four big ships plus smaller crafts

## **2.3 Relocatability**

The pier must not only be seaworthy, but also can be moved over long distances at reasonable speeds. Hence, the stream-lined, arrow-shaped configuration, and the retractability of the finger piers in Schemes A and B.

## **2.4 Rapid Deployability**

To be effective, the pier must be quickly operational upon arrival at site. In pursuit of this objective, the stiff-leg, single-point anchoring system has been developed for the use of the expeditionary pier.

## **3. DESIGN CONSIDERATIONS**

The following considerations have been assumed for the preliminary design of the pier, in addition to the four major criteria described above.

### **a. Materials**

Important criteria for the selection of structural materials must include lightness, strength and durability. Available materials that meet these criteria include lightweight concrete and steel. Either material is feasible and available. For the purpose of this investigation, lightweight concrete of 120 pcf density, and prestressing technique are envisaged.

**b. Environmental Loads**

The pier is designed for a wave height of 20 ft, in approximately sea state six, with wind velocity of 90 mph. The wavelength has been assumed to be equal to the length of the pier, for maximum sagging and hogging conditions.

**c. Fendering System**

Modern, fixed-position fendering systems could be used since both pier and ships move together with little variations. In the pier scheme, shown in this report, cell fenders of the buckling cylinder type have been used. These are mounted on the pier and located at such a level that they will always engage the berthing ships at the waterline region away from any hull protrusions.

**d. Self-propulsion**

Although the use of tugs is envisaged in moving the pier, a self-propulsion system on board the pier will be necessary to enable the pier to move under its own power in case of emergency. This system may well be needed to assist the anchoring system in keeping station during severe storm conditions.

**4. DESCRIPTION OF THE PIER**

The pier is essentially shaped like an arrow to reduce resistance against water during tow or operation. The difference between the three schemes presented herein, Schemes A, B and C, is in the inclusion of the finger piers in Scheme A and B, and the modification to the aft section of the pier in Schemes B and C. Scheme A, which is the original scheme, has two ships nesting against the back of the pier, i.e., perpendicular to the axis of the pier. In Scheme B, the aft section is modified to have the two ships berth alongside the pier in order to reduce current forces against the pier during operation. Scheme C is similar to Scheme B except it does not have the finger piers. The removal of the finger piers would bring the pier closer to the SOA, and make it more readily available for use in the near-term future.

As mentioned before the pier measures 940 ft in overall length. The hull for all three schemes is 51 ft deep, and when floating with normal live loads, takes a draft of approximately 34 ft., freeboard is therefore 17 ft. The hull is stiffened by structural walls that also serve as watertight bulkheads. Refer to Drawings 1 through 6.

**5. VALIDITY OF DESIGN**

The first task in this investigation is to confirm the validity of the preliminary design in general for the purpose of subsequent investigations. Specifically, the early design was checked to ensure that its structural system is adequate to withstand the assumed construction, towing and operation conditions, and that its

flotation and naval architectural characteristics are satisfactory. Considerable effort has also been made to resolve design problems posed by the two major innovations, i.e., the hinged joint for the finger piers and the stiff-legged swivelling suction anchor.

The results of this confirmatory investigation are contained in calculation sheets appended as Appendix A at the back of this report.

## **6. ANALYTICAL AND DESIGN FEASIBILITY**

The analysis and design of the expeditionary pier as represented in the drawings could be carried out with the state-of-the-art technology. This consists of design guidance provided by the various registration societies and technical and professional institutions. Similar prior design and constructions include the prestressed concrete pontoons that made up the Hood Canal Bridge in the State of Washington, the 460-ft. long prestressed concrete LPG barge that ARCO built for services in Indonesian waters, and the 700-ft. long prestressed concrete container pier now being built for Alaska's port of Valdez. This pier is 100 ft. wide and is made up of two 100 ft. by 350 ft. by 30 ft. deep pontoon units. The units are towed in from a fabrication yard 1,400 miles away, and joined and post-tensioned together upon arrival at the site. The pier is moored to eight hollow concrete gravity anchors each measuring 20 ft. square in plan and 13 ft. deep. The cost of this floating pier project was reported to be \$48 million.

The construction of our pier will be similar. It is different from the Valdez pier mainly in size.

Deficiencies in the state-of-the-art technology are present primarily in relation to the two innovations as mentioned before, i.e., the hinge joint for the finger piers and the stiff-legged swivelling single-point mooring involving a suction anchor. These are commented further as follows:

### **Hinge Joint Between Finger and Spine Piers**

The purpose of the hinge joint is to enable the finger pier to be retracted during tow. For easy connection, the joint is located at deck level and consists, as conceived, of a link mounted on the finger pier that is dropped into a pin mounted on the spine pier when the finger pier is maneuvered into position. The maximum tension or compression at each of the two connections has been worked out to be in the order of 5,280 kips. Although reversal of stress is unlikely, considerable stress variation that may range from 0 to the maximum of 7,800 kips is possible, and will require that fatigue conditions be considered in designing the joints.

A concept of the hinge connection is shown in Figure 9.

### **The Stiff-legged Swivelling Suction Anchor**

The stiff-legged single point swivelling anchoring system that is developed for the pier is considered most likely to succeed from among the various possibilities. The

challenge that is presented to the designer are represented in the requirement that, (1) the system must be capable of developing the unusually large holding force necessary to keep the pier/ship complex and on station and (2) the system can be quickly operational upon arrival at site.

The latter requirement also includes the expectancy of the pier to be able to be retrieved rapidly for quick departure.

These requirements will rule out anchoring systems that require long installation and retrieval times, or anchoring systems that would fix the orientation of the pier thus subjecting it to current forces from all directions. The pier must be made to turn and face the sea at all times in order to minimize the holding force on the anchor. This leaves only the single-point deadman type of anchors for consideration.

A deadman anchor normally consists of a large concrete box, measuring say 25 ft. by 25 ft. on plan, which is filled with ballast such as sand, gravel or lean concrete, after it is lowered to the sea bottom. It is unfortunately not very suitable for the purpose of our pier because of the impractically large size involved, and the difficulty of recovering the deadman upon departure of the pier from a location. The deadman may have to be cut loose and left behind.

The suction anchor will solve most of these problems because of its relatively smaller size and weight, its large holding power because it invokes the resistance provided by a relatively large body of soil mass, and the short installation and extrication times.

Uncertainties and problem areas are as follows:

1. Application limited only to soils that are penetrable by the suction anchor.
2. Limitation on anchor depth of water. The anchoring system as shown may be applicable to water depths of up to 80 ft.
3. The design of the swivelling joint at both ends of the stiff-leg.
4. The requirement of a swivelling connection to the anchor, for the suction system (or pressure system for the extrication of the anchor) that can rotate around the anchoring system together with the stiff-leg and the pier.
5. The inability of the hinge joint to take large and quick rotational movements.

## **7. MATERIAL FEASIBILITY**

No difficulty is foreseen in using lightweight concrete as the prime structural construction material for the pier. Lightweight concrete can be made in good and consistent quality under the present technology. It has also been proven as suitable material in marine applications. An oft-quoted example is the lightweight concrete ship, "SS Selma," which was built during World War I. After the war it was scuttled and sunk in tidal waters in Galveston Bay. When examined years later, both the

concrete and the reinforcement were found to be in excellent conditions even though some of the reinforcement was protected by a concrete cover of no more than half an inch.

The problem concerning material mainly boils down to one of quality control. Secondary problems do exist however. For example, if the pier is stationary in one location for a long period of time, it will have the problem of constantly removing marine growth outside the hull. The concrete could be coated, or additive could be included in the mix that will inhibit marine growth.

Deficiencies in present technology also include the development of fendering materials that can absorb much higher pressure than current practice, to be used in cushioning the impact between the finger and the spine piers. The pier will also need a repair system that can repair all except the most severe damage to the hull, quickly and effectively.

As an extension of the expeditionary pier concept, it will be useful to develop more energy-efficient equipment, possibly solar-powered, that will enhance and prolong the usefulness of the pier on duty overseas.

## **8. CONSTRUCTION FEASIBILITY**

Construction methods are already available to build concrete structures such as the expeditionary pier. Unless a large number of piers are constructed, it can be assumed that the pier, in view of its size, will be constructed in segmental units which are subsequently assembled and joined together to make up the whole pier. The size of the unit is generally limited to 300 or 400 ft. in both horizontal directions. There are several methods of constructing the segmental units. They could be constructed on a special-purpose barge, then launched into the water when completed to a certain stage. Alternatively, they could be built in a shipyard or dry-dock type of facility, on slipways, or in a flood basin, which is the method shown in Drawing Nos. 11 and 12. In this method, the construction site at sea front is excavated so that the base of the site is below the sea level by a depth that is sufficient for the partially completed lower portion of the pier section to be floated out. During construction the sea is kept out by a temporary dike. When the lower portion of the pier unit, which mainly consists of buoyancy chambers, is built, water is allowed into the flood basin to float the unit. The dike is then beached, and the unit towed to deeper sheltered waters where further construction is continued until completion.

Deficiencies in the state-of-the-art technology with respect to the construction of the pier also exist in the areas that had posed difficulties to design and analysis, i.e., the finger/spine pier connection and the single-point suction anchor. Specifically:

1. The hinge joint at both ends of the link that connects the finger pier to the spine pier will provide for rotational movement in the vertical and horizontal directions. However, the joint will not provide for torsional movement between the two piers although some of this movement could be

tolerated by introducing more looseness in the joint. A universal or ball joint will solve this movement problem, but it has yet to be developed for this application.

2. The problem of connecting service lines across the joint
3. The construction of a swivelling joint for the suction hose connected to the anchor, and the problem of controlling the lines to avoid them getting entangled with the other components of the anchoring system as it swivels about the anchor.
4. The joining of the pier units will pose construction problems because of their size. The joining method shown in Figure 7 is the SOA method today. It could conceivably be improved to provide for more tolerances or allow for greater construction variations, and shorter connection time.
5. Quality control. Although this is not a deficiency in the sense that it is beyond the state of the art, the control of the quality and the consistency of concrete in our case will assume greater importance in view of the magnitude of the construction. A special effort will have to be made to ensure proper and stringent quality control.

## **9. CONSIDERATION OF ALTERNATIVES**

As can be expected, an innovative concept is open for a vast range of possible alternatives, not only of the design relevant to a specific purpose, but also of a great variety of predictable situations for which the pier may be applied. The design as presented for the pier is therefore far from being a finished product. In earlier discussion in this report, three configurations of the pier have been presented, each incorporating modifications that have to do with reducing water resistance, and with removing the finger piers that may not be technologically ready if the pier is going to be constructed in the near-term future.

In view of the considerable size of the pier, it is conceivable that part of it, e.g., the finger pier, could be used as runways for military aircrafts, thus augmenting the role of the pier as a quasi-aircraft carrier. Figure 13 shows how the finger piers will look after their conversion into runways. By confining the runway to the forward part of the finger pier, it would still be possible to provide two berths along the lee side of the pier, thereby maintaining its berthing capacity to four destroyer class vessels in spite of the conversion. There is ample space below deck for the storage of planes and supplies to support the pier in this additional role.

## **10. CONCLUDING REMARKS**

This investigation has shown the technological feasibility of an expeditionary pier that can be readily deployed to provide the full berthing facilities and services to Navy ships operating overseas. The cost of such a pier will be high. However, its availability will provide the Navy with a new option in its operation overseas, the value of which cannot be determined solely in terms of cost.

The development of the full pier, i.e., as shown in Scheme A or B, will depend on the successful development of two major innovations, i.e. the connection between the finger piers and the spine pier, and the stiff-legged swivelling suction anchoring system. These innovations and the problems they pose can be solved with additional efforts and time, part of which may run parallel to the further development of the pier itself. They should not in any case hamper the development of the pier, since at worst, these difficulties could be removed by supplementing them with systems that are already within the state of the art. For example, the incorporation of a dynamic positioning system to supplement whatever conventional anchoring system that may be used, instead of the innovative stiff-legged swivelling mooring as conceived. What it boils down to is whether there is a need for such a pier. If there is, there is sufficient reason to believe that the pier could be developed, designed and constructed based on the state-of-the-art technology in a matter of a few years.

APPENDIX A  
EXPEDITIONARY PIER SCHEME A

Operating Speed = 6 Knots

GEOMETRY

SIZE = 140' x 170' x 150'

Weight = 139,000 TONS

Draft = Light Ship = 98'

Live Load = 142' 3 4/10" in SW  
Total 340' DECKS

Center of Gravity = X = 442' FROM BFT.  
Y = 305' FROM BOTTOM SIDE

Center of Buoyancy = 434' FROM BFT

Spine Roll Period = 10.3 SEC

Spine Pitch = 26 SEC

Engine Roll Period = 6.9 SEC

Engine Pitch = 6.2 SEC

LOADING

SEE STATE 6

Max. Wave Height = 20'

Wind Velocity = 20 KNOTS

Current Velocity = 6 KNOTS

(Direction of Spine Design)

Wave Velocity = 4 KNOTS FOR LOADING

MATERIALS

Light Weight Concrete 125 PCF

$F_c = 4000$  PSI (Spine & C) and  $F_c = 7000$  PSI (Anger)

Reinforcing Steel - Uncoated - Cold Wire Strand

ASTM A416, 3/8" - 1 1/2" -  $F_u = 120$  KSI

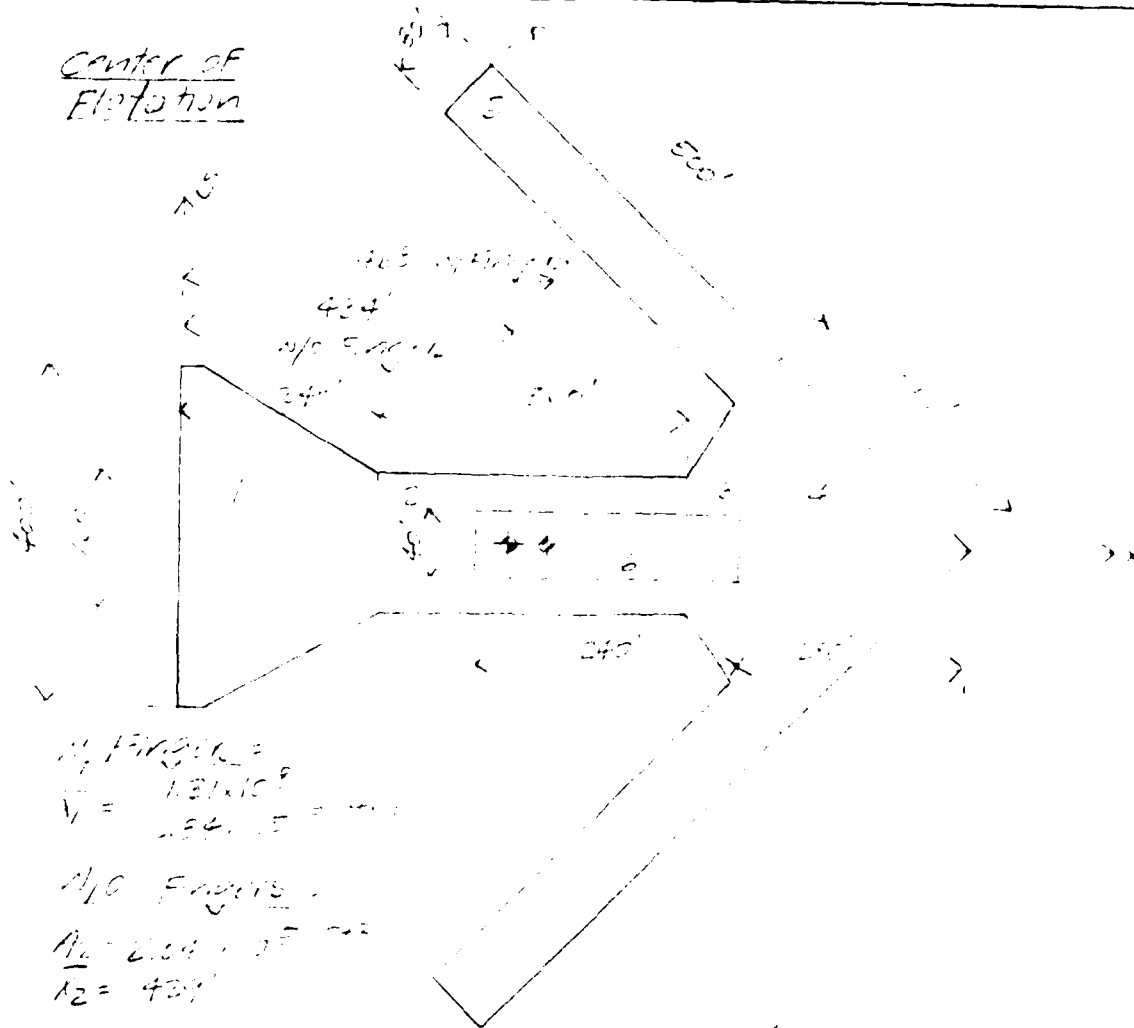
Reinforcing Steel - ASTM A615 Grade 60

Mild Steel - ASTM A36 Grade 50



PROJECT	NAVY FIERS
ITEM	EXPLOSION
DESIGN	CENTER OF EXPLOSION
DATE	11-5-51

4-2



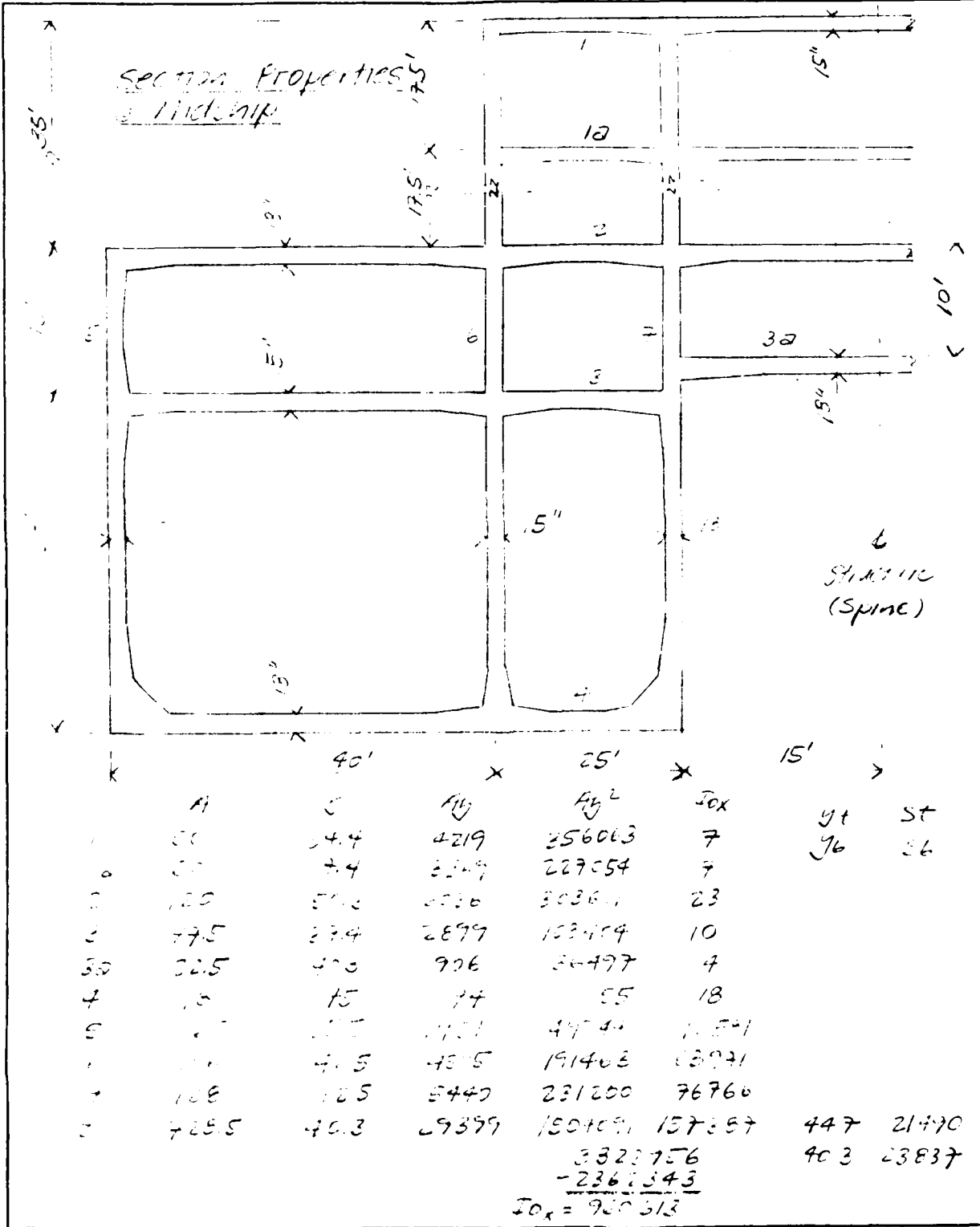
	$\Delta x$	$\Delta y$	$\Delta z$	$\Delta t$
1	34400	100	32000	$7.99 \times 10^8$
2	34600	400	34200	$1.02 \times 10^9$
3	35000	900	35000	$1.25 \times 10^9$
4	35000	1400	35000	$1.48 \times 10^9$
5	35200	1900	35200	$1.72 \times 10^9$
6	35500	2400	35500	$2.00 \times 10^9$

$$c = 2.94 \times 10^8$$
  

$$\frac{\Delta x}{\Delta t} = 7.99 \times 10^8 - 2.94 \times 10^8 \times 41^2 = 1.95 \times 10^{10} \text{ Fm}^2$$

$$\frac{\Delta y}{\Delta t} = 5.93 \times 10^{10} - 2.94 \times 10^8 \times 429^2 = 1.83 \times 10^{10} \text{ Fm}^2$$





PROJECT	ADRY PIERS
ITEM	EXPEDITIONARY PIER
DESIGN	ABS LIVE MOMENTS
DATE	1-22-84

SHEET  
A-4  
OF  
FILE NO.

Letter to a Young Soldier's Mother

4. A suitable bonding material <sup>2</sup> is

51490

$\Delta T = 140.21^\circ\text{C}$        $\Delta T = 145^\circ\text{C}$   
 $FC = 7500 \text{ Ft}$

12

$$M_2 = 10.5 \times \frac{1400 + 1400}{1000} = 2990 = 4.52 \times 10^3 \text{ kg} \quad \text{---} \quad \text{Ans}$$

20 Dec 1971

to the end of the spring term.

$$1.7_2 = 1.95_{21} - 1.2_2$$

*Mosses - Still in the same place*

$$C_{10} = \text{Molecular Weight} - \text{Inherent bonding element}$$

✓ - 0 For 0.75

$C_1 = 1.72$

$$C = 0.53 \cdot 10^{-4} + 0.57 \cdot 10^{-4} \cdot [0.02 + 0.53] \cdot 10^4 = 0.7110^{-4}$$

—

$\epsilon = 16''$

$H_0$  - Effective wave height of standard wave is Ft.  
 $= [4.5 L^{-1/4} + 0.16 L^{-1/2} + 0.25] \cdot 10^{-2}$   
 $= 0.0015$   $920 \leq L \leq 1000$  Ft.

$$A_{\text{net}} = 0.71 \text{ ft}^4 \cdot \text{lb}^2 / \text{in}^2 + 2650 \cdot 1.2 \cdot 0.24 \text{ K-ft} \\ = 5.9 \times 10^{-3} \text{ K-ft}$$

DETERMINE ALLOWABLE WAVE HEIGHT AT TOP OF TOWER

$$\frac{ALLOW. H}{MAX H_E} = \frac{H_E}{MW}$$

$$H_E = \frac{5.02}{5.9 \times 10^6} \times 20.9' = 20.9' > 20' \text{ satisfactory Section 6}$$

USE ABS RAILS TO DETERMINE ALLOWABLE WAVE HEIGHT FOR SHORTER PIER LENGTHS

FOR L = 900'

$$M_v = \frac{4.5 \times 10^6}{2} \times \frac{900^2}{100} \times 26.4 \times 1.24 = 26.4'$$

$$M_v = \frac{4.5 \times 10^6}{2} \times \frac{900^2}{100} \times 26.4 \times 1.24 = 26.4'$$

$$H = \frac{4.5 \times 10^6}{5.9 \times 10^6} \times 26.4' = 22.8' \text{ 1/210}$$

DETERMINE MAXIMUM ALLOWABLE MOMENT BY PROPORTION:

$$M_{max} = \frac{P}{H_E} \times MW = \frac{20'}{20.9'} \times 5.9 \times 10^6 = 5.6 \times 10^6 \text{ 1/210}$$

ABS Wave Barring Moment and Shear Distribution

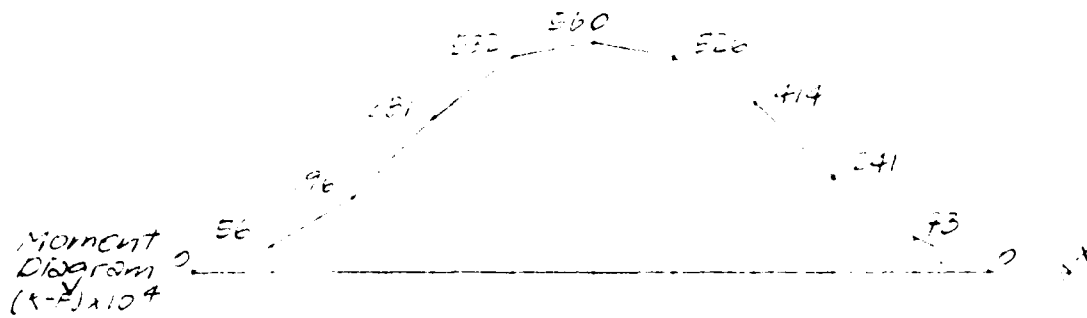
Max. =  $5.6 \times 10^6$  K-F  $L = 990'$ , Stations @ 94'

Station	loading Moment (wave height = 20')	
0	0	= 0
2	$2.10 \times 5.6 \times 10^6$	= 5600000
4	$2.35 \times 5.6 \times 10^6$	= 13200000
6	$2.6 \times 5.6 \times 10^6$	= 19080000
8	$2.85 \times 5.6 \times 10^6$	= 23200000
10	$3.0 \times 5.6 \times 10^6$	= 56000000
12	$2.94 \times 5.6 \times 10^6$	= 52640000
14	$2.74 \times 5.6 \times 10^6$	= 41440000
16	$2.43 \times 5.6 \times 10^6$	= 29080000
18	$2.0 \times 5.6 \times 10^6$	= 12800000
20	0	= 0

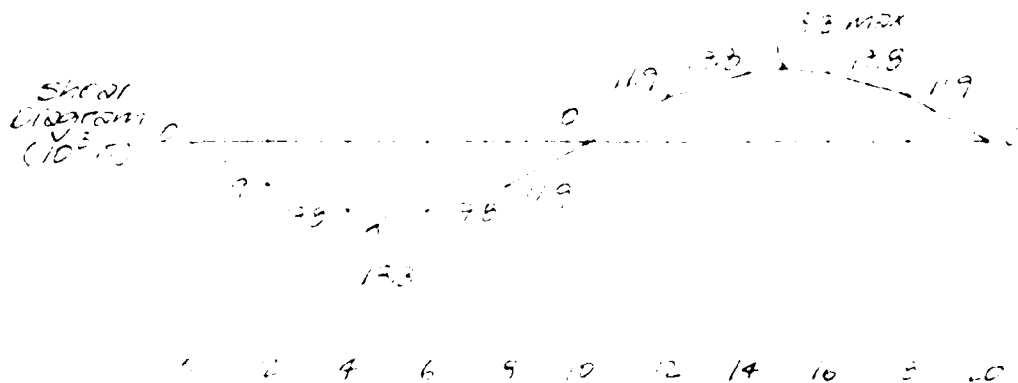
SHEAR FORCE

0	0	= 0
2	$5600000 / 47 =$	= 11915
4	$(23200000 - 5600000 - 11915 \times 94) / 94 + 11915$	= 17872
6	$19080000 - 17872 \times 94 =$	= 18295
8		= 17872
10		= 11915
12		= 0
14		= 11915
16		= 17872
18		= 18295
20		= 17872
22		= 11915
24		= 0

USMC Moment and Shear Envelopes



SPINE PIER



0 2 4 6 8 10 12 14 16 18 20

Spine Pier Loading: Supporting Columns

Primary Stresses  $M_{max} = 5600000 \text{ K-F}$

$$f_{top} = 5600000 / 21490 = 261 \text{ KSF} = 1310 \text{ PSI } (+)$$

$$f_{bot} = 5600000 / 5429 = 104 \text{ KSF} = 1021 \text{ PSI } (-)$$

Secondary Stresses of Bottom Slab: (+0.0')

a) At column due to buoyancy:  $3 @ 20'$   
longitudinal slab span  $20'$

Load Load:

$$\text{Concrete } 2110' \times 20' = 0.21 \text{ KSF}$$

$$\text{Arch + Misc.} = 0.10$$

$$\text{Buoyancy} = 2064 \times 20 = 0.10$$

Resultant

$$= -2.21 \text{ KSF}$$

no live load +/- supp)

max. compress supp)

Slab Section Properties:

Max Wave Loading  
(Wave Height = 20')

At Support  $e = 23"$  (assumed to mid-third of

$$I = 0.754$$

$$S = 0.6 + F^2$$

c) Moment =  $20 \times 10' \times 40' = 8000'$

$1/10 > 2.0 \rightarrow$  one-way slab

$$M_{max} = 11.4 \times 10^4$$

$$= 2.21 \times 10^2 / 4 = 6.2 \text{ K-F}$$

$$f_{top} = 17267 \times 1.23 = 2123 \text{ PSI } (+)$$

Secondary Stresses of Top Slab: (+95.0')

a) Loading:

$$\text{Load Load: Concrete } 8/10 \times 12 = 0.19 \text{ KSF}$$

$$\text{Arch + Misc.} = 0.10$$

$$\text{Live Load: } 0.400 \text{ KSF} = 0.40$$

$$\text{Total Load} = 0.684$$

Cont Spine Pier Stresses @ Top & Base:

a) Moment @ support  $M = W L_n^2 / 11$   $L_n = 19'$   
 $L_1 / L_n > 2.0$   $L_1 = 40'$   
 $C = 0.68 \times 19^2 / 14 = 15$

Sub Section  $L_n = 19'$  anchored @ support  
 $I = 1113 \text{ ft}^4$   
 $S = 238 \text{ ft}^3$

c) Stresses  $f = 1.9$   $1.9 \times 8 = 40 \text{ KSF}$   
 $1.9 \times 8 = 320 \text{ PSI } (\pm)$

Additional Compression Stresses due to Water Head:

a) Lead water

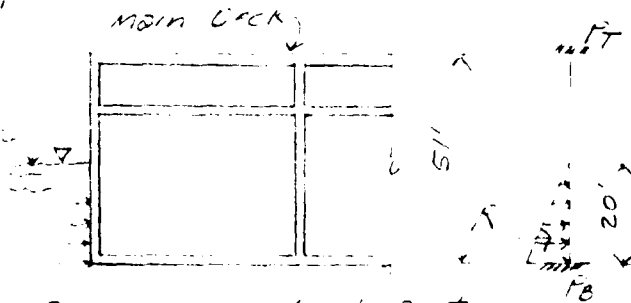
1) Lead load only, for maximum division  
Draft = 19.5'

Resultant Compression

Force  $F = 0.064 \times 100^2 \times 2$   
 $= 12.8 \text{ K}$

$f = 12.8 \times 12.9 / 51$   
 $= 1.67 \text{ K/ft}$

$f_2 = 12.8 - 1.7$   
 $= 11.1 \text{ K/ft}$



Spine longitudinal sect.

2) Subs.

Consider bottom only as top loading is taken by main deck which is not the critical one.

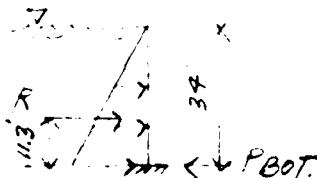
Bottom  $f/A = 11100 / 24 \times 12 = 37 \text{ PSI}$

Top  
b) Live load + Lead load  
Draft = 34'

Resultant  $F = 0.064 \times 100^2 \times 2 = 12.8 \text{ K}$

Force  $f = 12.8 \times 12.9 / 51 = 29 \text{ K/ft}$

$f_{top} = 37 - 29 = 8 \text{ K/ft}$



Cont' Still Water Head Stresses :

Stresses due to live + dead loads dist:

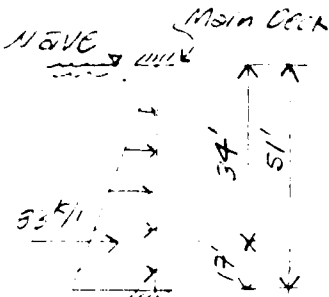
At support =  $T_{BOT} : 29000 / 24 \times 12 = 101 \text{ ksi}$   
 $T_{TOP} : 4000 / 18 \times 12 = 27 \text{ ksi}$

2) Wave Induced Water Head Stresses.

Assume avg. wave height of 20'

Total Water Head: Dead + Live loads + wave  
= 51' max  
Resultant =  $0.064 \times 51^2 / 2$   
= 83 k/ft

$T_{TOP} = 83 \times 17 / 51 = 29 \text{ k/ft}$   
 $P_{BOT} = 83 \times 34 / 51 = 55 \text{ k/ft}$   
Stresses:  $T_{BOT} = 55000 / 24 \times 12 = 144 \text{ ksi}$



Combination of Stresses :

	Max. Tension (ksi)		Max. Compression (ksi)	
	Long. (ksi)	Transverse (ksi)	Longitudinal (ksi)	Transverse (ksi)
Dead Load	1910		1631	1631
Seismic	±20	±20	521	—
E	2130	320	2152	1631
Water Head			+144	+144
Total Max.	2130	320	2296 ✓	1775 ✓

Longitudinal Prestressing:

Partial - max 40% of prestress necessary to offset shrink stresses due to general curling. The balance being taken by tension in the slab.

TRANSFORMED AREA = MAXIMUM PRESTRESS  
max. stress = 1456 PSI OF TOTAL CROSS-AREA  
 $40\% \times 1456 = 582.4 \rightarrow$  INCREASE  
OF 95% CROSS AREA

$$\text{PRESTRESS} = 2793 \times \frac{582.4}{1456} = 1162 \text{ PSI}$$

$$\text{SHRINK STRESS} = 1310 \times \frac{582.4}{1456} = 529 \text{ PSI}$$

$$\text{PRESTRESS TENSION} = 498 \text{ PSI (min. steel)}$$

Final Stresses For Slab Prestressing (compression)

STRESS (PSI)      Longitudinal      Transverse

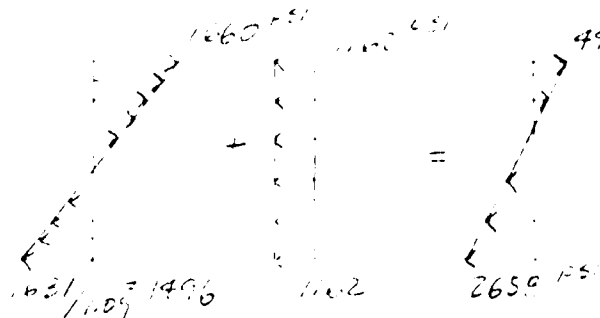
Shrink curling      1310      2793  
(582.4 - PRESTRESS)

Slab curling      529      144  
(582.4 - PRESTRESS)

S (PSI)      5373      2937

$$F_c \text{ REQUIRED} = 5373 - 45 = 7394 \text{ PSI}$$

$$100 \text{ PSI} = 2500 \text{ PSI} \quad \text{light weight concrete}$$



Total  
Prestressing Force:  
 $1162 \times 144 \times \frac{KSF}{1000} \times 1456 \text{ SF}$   
 $= 243,630 \text{ K FORCE}$

(Shrink curling + Prestressing = Final Primary Stresses)

WIND & EARTHQUAKE (WIND ENGINEERING)

Wind Load:

Top of Pier:

$$F_{top} = 0.0025 \times 145 \times 1200 \times 140000 = 50784 \text{ k}$$

$$F_{top} \text{ (uplift)} = 0.005 \times \frac{1}{2} \times 10 \times 1200 \times 140000 = 16800 \text{ k}$$

$$F_{top} \text{ (down)} = 0.005 \times 10 \times 1200 \times 140000 = 16800 \text{ k}$$

$$F_{top} \text{ (side)} = 0.12 \times 15 \times (2000 + 7000) \times 4 = 9750 \text{ k}$$

$$\text{Total} = 91446 \text{ k}$$

$$\Sigma \text{ Wind Load} = 1000 = 34400 + 7400 = 75800 \text{ k}$$

$$F_{side} = 0.12 \times 15 \times 953 \times 500 = 8718 \text{ k}$$

$$F_{side} \text{ (uplift)} = 0.12 \times 15 \times (1000 + 1000) \times 1000 = 3600 \text{ k}$$

$$F_{side} \text{ (down)} = 0.12 \times 15 \times (1000 + 1000) \times 1000 = 3600 \text{ k}$$

$$F_{side} \text{ (side)} = 0.12 \times 15 \times (2000 + 1000) \times 47 = 1190 \text{ k}$$

$$F_{side} = 0.12 \times 15 \times 953 \times 1000 = 16658 \text{ k}$$

$$F_{side} = 0.12 \times 15 \times (2000 + 1000 + 1000 + 1000) \times 1000 = 9175 \text{ k}$$

$$\text{Total side load} = 145812 \text{ k}$$

$$F_{side} \text{ (uplift)} = 0.005 \times 15 \times 953 \times 1000 = 1074 \text{ k}$$

$$F_{side} \text{ (down)} = 0.005 \times 15 \times 953 \times 1000 = 10740 \text{ k}$$

$$\Sigma \text{ side load} = 166590 \text{ k}$$

$$\text{Total Wind Load} = 91446 + 166590 = 258336 \text{ k}$$

Earthquake:

$$F_{earth} = 0.25 \times 100000 = 25000 \text{ k}$$

$$F_{earth} = 0.65 \times 20000 = 13000 \text{ k}$$

$$F_{earth} = 0.15 \times 100000 = 15000 \text{ k}$$

$$\text{Assumed } F_{earth} = 25000 \text{ k}$$

$$\text{Total Earth Load} = 49000 \text{ k}$$

Roll Period:

Weight:

$$204,000 \text{ lbs} \times 1.6336 \text{ K} = 333,600 \text{ lbs}$$

$$\begin{aligned} \text{Total Weight} &= 11.8' + 132,000 \text{ lbs} \\ &= 19.5' + 17.8' \\ &= 37.6' \end{aligned}$$

VERTICAL LOAD OF GRAVITY H UNDER FULL LOAD:

$$\begin{aligned} H &= (28,440 \times 40) + (10,910 \times 20.5) + (100,000 \times 17.8) + (28,100 \times 50) + (90,000 \times 75) \\ H &= \frac{19,276,932}{490,664} \\ &= 40.4' \text{ FROM BASE AND} \end{aligned}$$

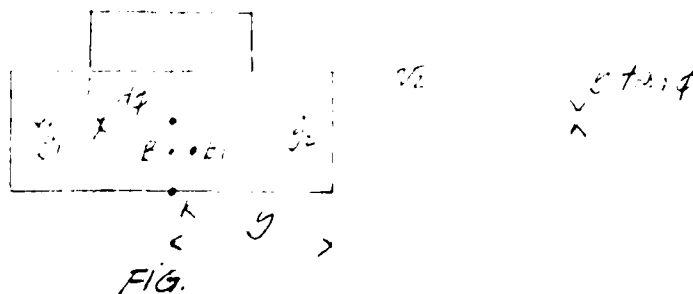
CENTER OF GRAVITY:

$$KE = 40.4/2 = 20.2' \text{ ABOVE BASE AND}$$

Static Load:

$$W = 250 \text{ lbs} \times 17.8' = 4,450 \text{ lbs}$$

Diagram of the structure:



$$\overline{EM} = \frac{251}{20.16} = \frac{20 \times 9.92}{7 + 2.24}$$

$\nabla$  Volume of Displacement  
= 54

$\overline{C}$  = Center of Gravity w.r.t. C

Rolling Angle  $\phi =$

$$\overline{C} = \frac{20 \times 9.92}{20 + 2.24} = 2.17'$$

$$\overline{C} = \frac{20 \times 9.92}{20 + 2.24} = 2.17'$$

$$\overline{C} = 2.17'$$

$$\overline{KM} = \overline{KE} + \overline{EM}$$

$$\overline{KE} = 20.2'$$

$$\overline{KM} = 20.2' + 2.17' = 22.37'$$

$$\overline{C} = 2.17'$$

$$\overline{C} = 2.17'$$

$$\overline{C} = 2.17'$$

$\overline{C} = 2.17'$  = Distance from Keel to Center of Gravity

$\phi$	$\nabla$	$\overline{C}$	$\overline{KM}$	$\overline{EM}$	$\overline{KE}$	$\overline{GM}$	$T_R$
10°	54	2.17	22.37	105	125	35	9.9
20°	54	2.17	22.37	105	125	35	10.0
30°	54	2.17	22.37	105	125	35	10.1

Rolling Period  $T_R = 2\pi \sqrt{\frac{I_{xx}}{W \cdot \overline{GM}}}$

$$M_H = W \times \overline{GM} \times \sin \phi$$

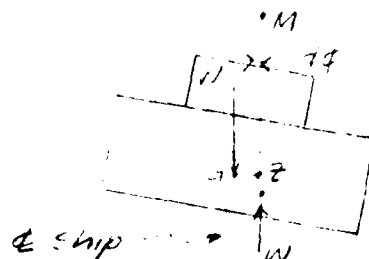
$$= 490664 \times 1.49'$$

$$= 732183 \text{ Lb-Ft}$$

$W$  = Weight of Ship

$\overline{GM}$  = Metacentric Arm

$$= \overline{GM} \sin \phi = 1.49'$$



PROJECT	WALL PILES
ITEM	EXISTING WALL PILE
DESIGN	WALL PILE
DATE	8/82 KAS

SHEET	A-15
OF	
REVISION	

$$GM = \frac{J}{V} = \frac{J}{7.67 \times 10^6}$$

$$\theta = 10^\circ$$

$$J = \frac{\pi}{32} (10.2)^4 = 422614 \text{ in}^4$$

$$V = 214000 \times 37.6 \times 100 = 7.67 \times 10^6 \text{ in}^3$$

$$GM = \frac{J}{V} = \frac{422614}{7.67 \times 10^6} = 0.055$$

$$L_{NL} = \frac{422614 \times 0.055}{7.67 \times 10^6} = 345'$$

$$LM = 20.2' + 345' = 365'$$

$$GM = 365 - 40.4 = 325'$$

$$T_{pitch} = \frac{1.57 \times 10^6}{325} = 2.5 \text{ sec.}$$

$$\phi = 10^\circ \rightarrow 1.47 \text{ rad} \rightarrow 27 \text{ sec.}$$

### Finger Piers

Use Finger Piers to represent the structures as  
interaction forces between main pier and finger  
pier does not provide any significant forces.  
Finger pier will not be a design force at the interface  
of the main pier and the design pier connections.

1.0 pier 1.0 pier

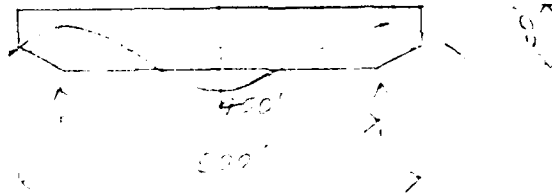
1.0 pier 1.0 pier

1.0 pier 1.0 pier

1.0 pier 1.0 pier

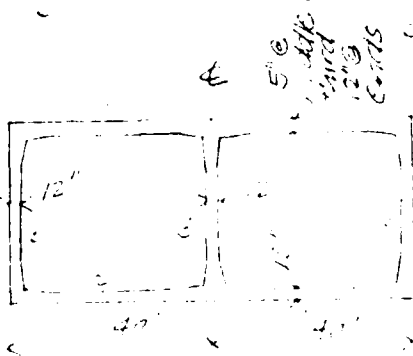
Section  
Properties

1.0 pier



Section Properties & Analysis

1.0 pier 1.0 pier 1.0 pier 1.0 pier



A	A <sub>g</sub>	I <sub>g</sub>	I <sub>c</sub>	I <sub>e</sub>
96	39.4	2820	82908	10
76	2.03	60	28	15
90	15	1330	20005	2750
282	15	4030	109927	15
			63450	
			46477	

Section Properties

$$S_x = S_y = 46477$$

$$= 5098 \text{ ft}^3$$



INTERNATIONAL  
STRUCTURAL ENGINEERING  
315 Bay St., San Francisco, Ca 94133

PROJECT NAVA WALS

ITEM Finger Pier #1

DESIGN NAVE 100 M.T.

DATE 11-30-17

SHEET

A-17

OF

REVISION

### ENVIRONMENTAL LOADS

#### NAVE 100 M.T. - Primary Stresses

Finger Pier #1 is built in two stages. Built one 140' long segment and then to 400' long. Flow down construction is not sealed separately and it will connect at first pier.

Maximum wave height and occur while pier is in service. That is in the open ocean. Design Finger Pier for 10' high, 400' long NAVE. (See Station) a reduction in forces caused by calm water - Environment.

#### TOTAL BENDING MOMENT = ABS RULES Section 6.5.2)

$$M_T = M_{WT} + M_W$$

$M_{WT}$  = CALM WATER BENDING MOMENT =

= 0 as pier is built in structure is approximately uniform. Then pier is built and under at end of pier from the design service condition. This pier is built and under service condition with the maximum wave height forces.

$$M_{WT} = 0.5 \times 100 \times 10$$

$$= 500 \times 10 = 5000$$

$$= 5000 \times 10 = 50000$$

$$= 50000$$

$$M_{WT} = 0.181,500 - 11,500$$

$$= 20,500$$

$$M_W = 0.181,500 + 11,500 = 193,000$$

$$= 193,000 \text{ K.F}$$

#### Minimum Allowable Bending Moment:

$$M_{min} = C \times F$$

$$C = 0.45 \text{ (Minimum Impulse Stress KSI)}$$

$$F = 6500 \text{ PSI}$$

$$C = 0.45 \times 6500 = 2925 \text{ KSI}$$

$$= 2925 \text{ K.F}$$

Calc. Max. Allowable Bending Moment:

$$S_x = 3098 \text{ in}^4$$

$$M_{all} = 211 \times 3098 = 653678 \text{ K-F}$$

Determine Max. Allowable Height by Flexure:

$$\frac{M_{all} \cdot H}{I_{max} \cdot M_E} = \frac{M_E}{M_{all}} \cdot H_C \rightarrow H_{all} = \frac{M_E}{M_{all}} \cdot H_C$$

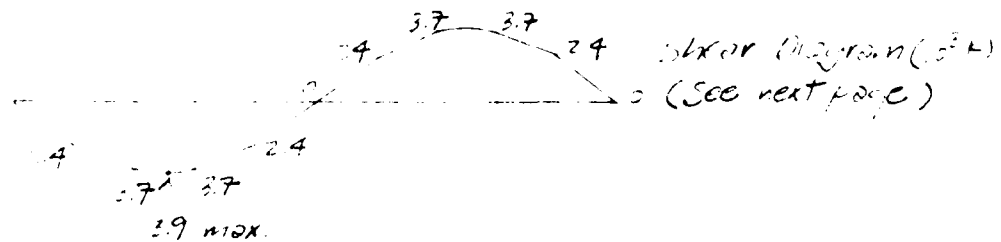
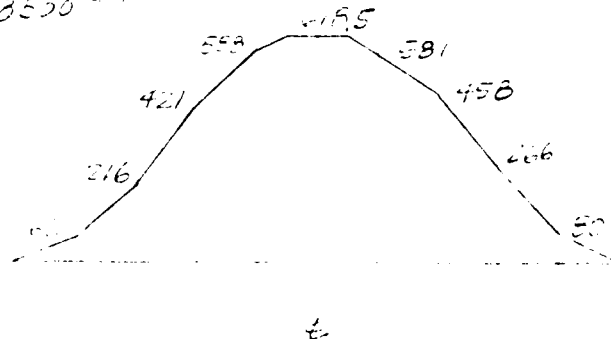
$$H_{all} = \frac{653678}{624000} \cdot 20' = 21.1' > 20'$$

Max. Allowable Height is above L.C. limit of Sec. 5.10.6

$$\text{For } H=20' \rightarrow M_{max} = 20/20.5 \times 624000 = 618537 \text{ K-F}$$

Ass. Allow. Section Moment Distribution: Table 6.1

$$M_{all} = 618500 \text{ K-F}$$



3.7' 3.7' 24' 24' 3.7' 3.7' 3.7' max.

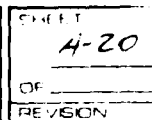
WIND: EXERCISE 1, 1000000 LBS (450 KIPS)

DESIGN: EXERCISE 1, 1000000 LBS (450 KIPS)

0	0	= 0	K-F
1	216475	= 216475	
2	216475	= 216475	
3	216475	= 420590	
4	216475	= 587075	
5	216475	= 619500	
6	216475	= 651990	
7	216475	= 684475	
8	216475	= 716955	
9	216475	= 749405	
10	216475	= 781850	
11	216475	= 814295	
12	216475	= 846740	
13	216475	= 879185	
14	216475	= 911630	
15	216475	= 944075	
16	216475	= 976520	
17	216475	= 1008965	
18	216475	= 1041410	
19	216475	= 1073855	
20	216475	= 1106300	

(WIND FORCE) (K)

0	0	= 0	
1	(216475/500) 2	= 2474	
2	(216475 - 61950) 2	= 2474	
3	(216475 - 61950) 2	= 2474	
4	(216475 - 61950) 2	= 2474	
5	(216475 - 61950) 2	= 2474	
6	(216475 - 61950) 2	= 2474	
7	(216475 - 61950) 2	= 2474	
8	(216475 - 61950) 2	= 2474	
9	(216475 - 61950) 2	= 2474	
10	(216475 - 61950) 2	= 2474	
11	(216475 - 61950) 2	= 2474	
12	(216475 - 61950) 2	= 2474	
13	(216475 - 61950) 2	= 2474	
14	(216475 - 61950) 2	= 2474	
15	(216475 - 61950) 2	= 2474	
16	(216475 - 61950) 2	= 2474	
17	(216475 - 61950) 2	= 2474	
18	(216475 - 61950) 2	= 2474	
19	(216475 - 61950) 2	= 2474	
20	(216475 - 61950) 2	= 2474	



LOAD: FINGER PIET STRESSES @ TOP SLAB:

a) Moment:  $M = wL^2/11$   
 $= .55 \times 17^2/11 = 1.3 \text{ K-F}$

b) Section Prop:  $I = 116 \text{ FT}^4$   
 $t = 15$   $J = 0.06 \text{ FT}^4$

c) Stresses:  $f = M/S = 1.3/0.26 = 4.9 \text{ KSE}$   
 $= 491 \text{ PSI} \pm$

COMBINATION OF STRESSES:

	Max Tension (PSI)		Max Compression (PSI)	
	Longitudinal	Transverse	Longitudinal	Transverse
Wind	1386	1386	1086	1386
Seismicity	291	—	356	—
Σ	1867	1386	2142	1386
Water Head	—	-16	+106	+106
Total Max.	1867	1370	2248 ✓	1492 ✓

\* 1/2" TYPICAL CRIPPLED LINE TO WATER HEAD

1) Static Water:

5' Load (1/2" x 1/2")  $\times$  10' =

Resultant:  $10 \times 10 \times \frac{1}{2} = 32 \text{ K}$

Finger pier

$F_T = 32 \times \frac{1}{2} \times \frac{1}{30} = 1.55 \text{ K}$   
 $F_B = 2.85 \text{ K}$

Seismicity



NOTE: These reactions are high, since exterior slab also spans horizontally

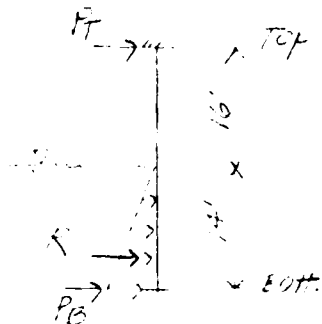
2) Wind:

Top:  $f = 1.55 \times 15.12 = 1.9 \text{ KSE}$  more

Bottom:  $f = 2.85 \times 15.12 = 16 \text{ PSI}$

CONT' WATER HEAD STRESSES (SHALL WATER)

- 2) LIVE LOAD + DEAD LOAD, CRIFT = 14'  
(UNDER 250 PSF LIVE LOAD)



$$\text{Resultant} = 2004 \times 14 \times 1/2 = 6.3 \text{ ft}$$

AT  $47' = 47'$  FROM BOTTOM

Reactions:

$$R = 2.3 \times 47 / 30 = 10 \text{ ft}$$

$$R_B = 5.3 \text{ ft}$$

STRESSES DUE TO CRIFT OF DEAD + LIVE:

$$F_{\text{TOP}} = 1000 \text{ lb/ft} \times 12 = 5.5 \text{ ft}$$

$$F_{\text{BOT}} = 5300 \text{ lb/ft} \times 12 = 2.7 \text{ ft}$$

2) WAVE HEIGHT

ASSUME WAVE HEIGHT OF 30'

$$\text{Resultant} = 2004 \times 30^2 / 2 = 21 \text{ ft}$$

$$R = 2.3 \times 30 = 10 \text{ ft}$$

$$R_B = 2.9 \times 30 = 19 \text{ ft}$$

Stresses:

$$F_{\text{TOP}} = 1000 \text{ lb/ft} \times 12 = 5.5 \text{ ft}$$

$$F_{\text{BOT}} = 19000 \text{ lb/ft} \times 12 = 10.6 \text{ ft}$$

### Experimental Provisions

1. Assume 75 CF of steel is used in the HPR. The steel is assumed to be in the form of a single layer of bars. The steel is assumed to be in the form of a single layer of bars. The steel is assumed to be in the form of a single layer of bars.

$$\text{Total Force} = \text{Area} \times \text{Stress} = 75 \text{ CF} \times 100 \text{ PSI} = 7500 \text{ PSI}$$

$$\text{Total Force} = 7500 \text{ PSI} \times 1.40 = 10500 \text{ PSI}$$

$$\text{Total Force} = 10500 \text{ PSI} \times 1.40 = 14700 \text{ PSI}$$

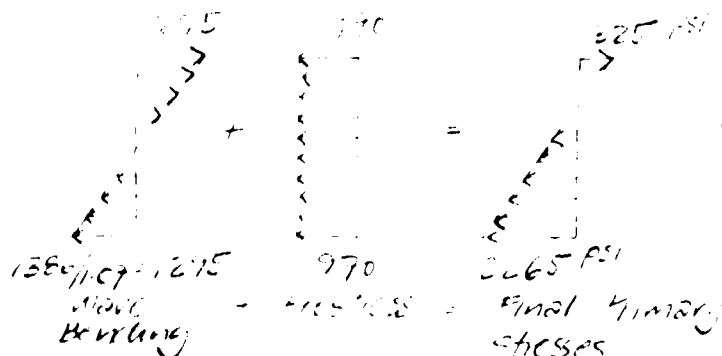
$$\text{Total Force} = \frac{1386}{1.07} = 1295 \text{ PSI}$$

$$\text{Residual Tension} = 1295 - 970 = 325 \text{ PSI (min steel)}$$

### Experimental Provisions (Compression)

2. Assume 75 CF of steel is used in the HPR. The steel is assumed to be in the form of a single layer of bars. The steel is assumed to be in the form of a single layer of bars.	750 + 106 = 856	856
3. Assume 75 CF of steel is used in the HPR. The steel is assumed to be in the form of a single layer of bars. The steel is assumed to be in the form of a single layer of bars.	750 + 106 = 856	856
4. Assume 75 CF of steel is used in the HPR. The steel is assumed to be in the form of a single layer of bars. The steel is assumed to be in the form of a single layer of bars.	750 + 106 = 856	856

$$\text{Total Force} = 10000 \text{ PSI} \rightarrow 7000 \text{ PSI}$$



$$\text{Total Posttensioning} = 1.40 \text{ KSF} \times 282 \text{ SF} = 39480 \text{ K}$$

# Finger Floor Weights:

## Dead Loads:

$$\bar{A} = 282 \times 1/2 + 263 \times 2/3 = 270^{SF}$$

$$\text{WALL} = 11.00 [ 270^{SF} \times 500 + 11,345,339 \text{ lbs} ]$$

$$= 1,441 \text{ K}$$

$$\text{K. WALL} = 11.00 \times 15 \times 2 \times 12 \times 12$$

$$= 1331 \text{ K}$$

$$\text{E.} = 50090$$

$$\text{FLOORING} = 0.035 \times 270 \times 4000$$

$$= 507 \text{ K}$$

$$\text{ME. FLOORING} = 0.100 \times 40000$$

$$= 4000 \text{ K}$$

$$\text{Total Dead Load} = 24639 \text{ K} \leftarrow$$

W. J. C. J. M. S. to keep floor height  
at finger floor same as expectations for  
the most modern lift truck and at the  
same time a 20 ft. floor should be provided  
to support other floor loads and to  
be distributed in order to bring main floor  
at same level.

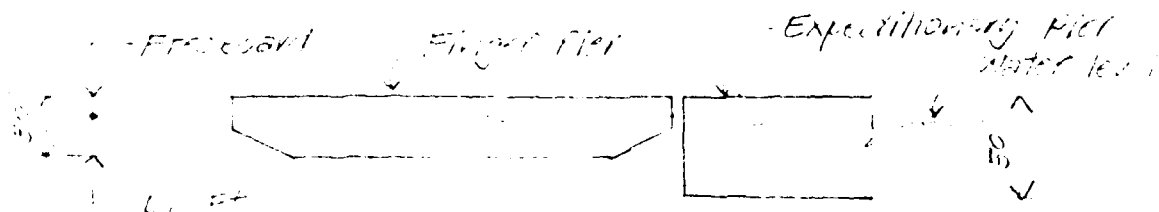
W. J. C. J. M. S. one means storage tanks,  
oil, fuel tanks, weapons, etc.

W. J. C. J. M. S.	W. J. C. J. M. S.	W. J. C. J. M. S.	E	W. J. C. J. M. S.	W. J. C. J. M. S.
W. J. C. J. M. S.	W. J. C. J. M. S.	W. J. C. J. M. S.	(K)	(FT)	(FT)
0	0	24639	24639	9.6	20.6
100	5000	"	29639	11.0	19.0
200	10000	"	34639	12.6	17.4
300	15000	"	39639	14.2	15.8
400	20000	"	44639	15.7	14.3
500	25000	"	49639	17.3	12.7
600	24000	"	48639	19.8	11.2

LIFT AND FREEDOM

Expeditionary Pier Minimum Live Load Lift: 17.8'  
DUE TO LIVE LOAD AVERAGE = 520 PSF  
Total Tension Area = 378400 sq

LIVE LOAD RANGE (PSF)	TOTAL LIVE LOAD (K)	TOTAL DEAD LOAD (K)	TOTAL (K)	LIFT (FT)	FREEDOM (FT)
0	0	255600	255600	19.6	30.4
100	37840	"	293440	22.5	27.5
200	75680	"	331280	25.4	24.6
300	113520	"	369120	28.3	21.7
400	151360	"	406960	31.2	18.8
500	189200	"	444800	34.1	15.9



LIFT AND FREEDOM COMPARISON

Expeditionary Pier	Flight Pier	L
Free (ft)	Free (ft)	Free (ft)
LIFT AND FREEDOM	LIFT AND FREEDOM	LIFT AND FREEDOM
30.4	30.5	9.9 Exp.
27.5	27.5	12.0 Exp.
24.6	24.6	14.2 Exp.
21.7	21.7	16.4 Exp.



INTERNATIONAL  
STRUCTURAL ENGINEERING  
315 Bay St., San Francisco, Ca. 94133

PROJECT: Navy Pier

ITEM: Expeditionary Pier

DESIGN: Draft and Freeboard

DATE: 11/82 KM

SHEET:

A-26

OF

REVISION:

### Joint Freeboard Comparison:

#### Summary:

- In order to maintain same freeboard between Finger and Expeditionary Pier, either one of the pier must be bolstered. Assuming that damage to the equivalent most common one load in the Exp. is 400 KIP, then the additional uniform load in the Finger Pier must be around 330 PSF in order to maintain same freeboard of 19.5 ft.
- The minimum average superimposed load in the Expeditionary Pier should be around 330 PSF so that the maximum freeboard allowed of 20.5 ft. is not exceeded.
- Since the freeboards of the two structures will most likely be different due to the action of waves, wind and current it is necessary to joint the piers with either a hinge, free of rotation or chain like type of connection.
- To keep freeboard differences to a minimum there should be a system in situ that monitors freeboards and adjusts either pier in order to put the decks of both structures.

Roll Period:

DRAFT:

$$\text{Lead load draft} = \frac{24639^k}{2.064 \times 50 \times 500} = 9.6'$$

Live load draft:

$$3 \times 1501^k = \frac{6000}{2.064 \times 50 \times 500} = 2.34'$$

$$\Sigma (12 + 2.34) = 11.9'$$

Vertical Center of Gravity + under lead + live loads

$$H = \frac{24639^k \times 15' + 6000^k \times 30'}{30639^k} = 17.9' \text{ (From bottom)}$$

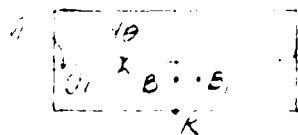
Center of buoyancy

$$KB = 17.9' / 2 = 9' \text{ From base line.}$$

Block coefficient at Draft 1.9

$$C_b = \frac{354}{L \times B \times d} = \frac{354}{40000 \times 1.9 \times 2.24 / 35} = 1.0$$

Transverse Metacentric Height



$$GM = \frac{KB - KG}{\tan \phi} = \frac{V \times g \times \overline{G_1 G_2}}{W \times \tan \phi}$$

for a small angle  $\phi$

$$V = 10^6 \text{ cu ft} \quad \text{kg} = 50'$$

$$V = L \times B \times d \times C_b = 40000 \times 1.9 \times 2.24 / 35 = 176 \times 10^3 \text{ ft}^3$$

$$\overline{G_1 G_2} = 4/3 \times y = 53'$$



INTERNATIONAL  
STRUCTURAL ENGINEERING  
315 Bay St. San Francisco, Ca 94133

PROJECT: Navy Piers

ITEM: Expeditionary Pier

DESIGN: Finger Pier Periods

DATE: 10-82 KM

SHEET:

A-28

OF

REVISION:

### Cont' Finger Periods:

$$\overline{KM} = \overline{KB} + \overline{BM}$$

$$\overline{KB} = 9' \text{ From Base}$$

$$\overline{GM} = \overline{KM} - \overline{KG}$$

$$\overline{KG} = H = 17.9' \text{ From Base}$$

$$\text{For } \phi = 10^\circ$$

$$V = \frac{1}{2} 40^2 \tan 10^\circ \times 500'$$

$$= 70531 \text{ F}^3$$

$$\overline{BM} = \frac{70531 \times 53}{476 \times 10^2 \times \tan 10^\circ} = 44.5'$$

$$\overline{KM} = 9 + 44.5 = 53.5'$$

$$\overline{GM} = 53.5 - 17.9 = 35.6'$$

$$\Delta \text{CH PIER} \cdot T\phi = \frac{\overline{CB}}{\overline{GM}}$$

$$C = 0.52 \text{ (Pontoon)}$$

$$\overline{E} = 80'$$

$$T\phi = \frac{0.52 \times 80}{\sqrt{35.6}} = 6.7 \text{ SEC} \quad \leftarrow$$

### Pitch Period:

$$\overline{BM}_L = \frac{V \cdot \overline{GL}^2}{V \tan \phi}$$

$$\text{For } \phi = 10^\circ$$

$$V = \frac{1}{2} \left( \frac{500}{2} \right)^2 \tan 10^\circ \times 80 = 440.8 \times 10^3 \text{ F}^3$$

$$V = 40000 \times 11.7 \times 1.7 = 476 \times 10^2 \text{ F}^3$$

$$\overline{GL} = \frac{1}{3} (500/2) = 83.3'$$

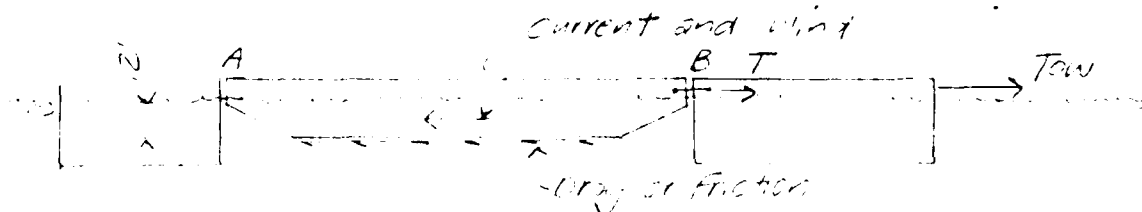
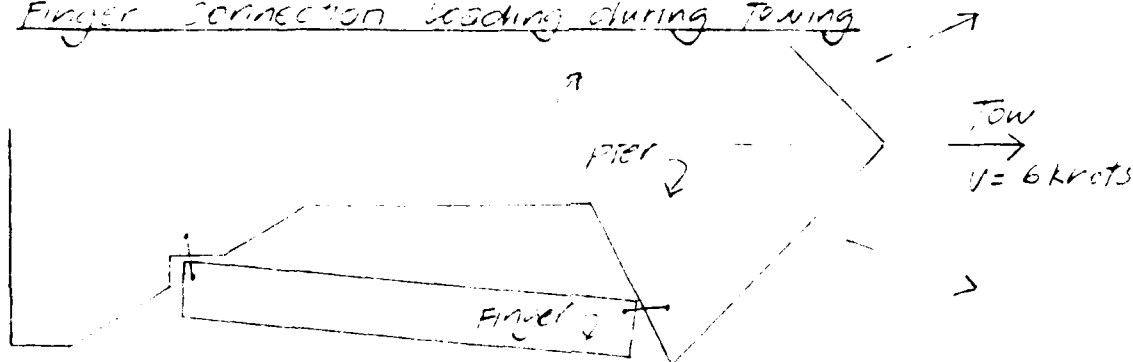
$$\overline{BM}_L = \frac{440.8 \times 10^3 \times 83.3}{476000 \times \tan 10^\circ} = 1749'$$

$$\overline{KM} = 9 + 1749 = 1758'$$

$$\overline{GM} = 1758 - 17.9 = 1740'$$

$$\text{Pitch} = \frac{0.52 \times 500'}{\sqrt{1740}} = 6.2 \text{ SEC} \quad \leftarrow$$

Finger Connection Loading during Towing



Forces caused by Resistance of Finger to motion must be taken by connections @ A and B

Resisting Forces:  $R = R_F + R_T + R_{fr}$

5) Frictional Resistance  $R_F$  (Finger Resistance)

$$R_F = F S V^{1.825}$$

$$F = \text{Frictional Coefficient (from Table 4, Chap. III, Distort. Model Architects, Etc.)}$$

$$= 0.0008$$

$$S = \text{Wetted Surface Area (sq. ft.)}$$

$$= 17.15 \times 12 = 205.8 \text{ ft}^2$$

$$V = \text{Velocity of Ship} = 6 \text{ knots}$$

$$R_F = 0.0008 \times 205.8 \times 6^{1.825} = 1.8 \text{ k}$$

$$R_F = 0.0008 \times 205.8 \times 6^{1.825} = 1.8 \text{ k}$$

Finger Resistance to Motion - Cont.

b) Wave Making + Eddy Resistance =  $R_r$

From Fig. 15 Naval Architects - Water  
 $V = 6 \text{ knots} = 500'$   
Interpolate to Find  $R_r = 3K$

c) Air Resistance :  $R_{air} = 40 \text{ mph}$

$$F_{air} = C_{yw} \cdot \frac{\rho}{2} \cdot V^2 \cdot A_s$$

Wind @  $90^\circ$  to longitudinal axis

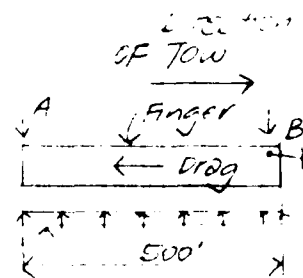
$$V_{air} = 40 \text{ mph} \times 5280 / \text{mile} / 3600 = 59 \text{ ft/sec}$$

$$C_{yw} = 1.0$$

$$\rho = 0.00237 \frac{\text{lb}}{\text{ft}^3} @ 66^\circ \text{F}$$

$$R_{air} = 1.0 \cdot \frac{1}{2} \cdot 0.00237 \cdot 59^2 \cdot 500 \cdot 12'$$

$$= 37K$$



d) Current Resistance :  $V_c = 4 \text{ knots @ } 90^\circ \text{ to longitudinal axis}$   
Assume that the current acts w/ 40 mph wind during towing

$$R_c \approx 1.46 V_c^2$$

$$R_c = 1.5 \times 6000 \times V_c^2$$

$$= 404K$$

$$k = 1.5$$

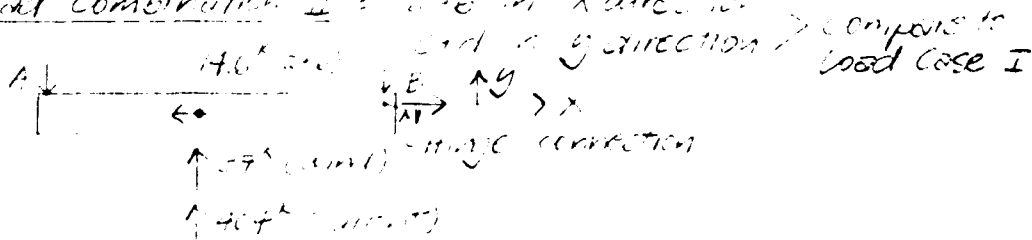
$$A = 500' \times 12'$$

$$= 6000 \text{ ft}^2$$

$$V = 17 \text{ ft/s}$$

Force - Body

Load Combination II : due in x direction



$$\sum F_x = 0 \Rightarrow F_x = 0 \quad \sum F_y = 0 \Rightarrow F_y = (221 + 404) / 2$$

$$= 221K$$

$$\sum F_x = 0 \Rightarrow B_x = 146K$$

$$\text{Tension @ B} = (221^2 + 146^2)^{1/2} = 222K < 5280K$$

Appendix : Environmental and Calculations:

Exped. Pier Loading

General Wind Loading

11/22

For loading  $P_{wind}$

Wind speed to ship  $C_{wp} = 1.0$

Exposure factor  $C_{ex} = 1.0$

Wind direction  $C_{fd} = 1.0$

At HULLS velocity,  $V = 90 \text{ mph} = 132 \text{ ft/sec}$

$A = \text{Pier + Deck Area}$

Exposure Factor  $C_{ex} = \frac{470' + 2' \times 35'}{470'}$

$L = 470'$   $H = 35'$   $A_g = 8800 \text{ ft}^2$  (470' x 35')

$C_{ex} = \left( \frac{470' + 2' \times 35'}{470'} \right)^{.65} (8800)$   
 $= 1.0$

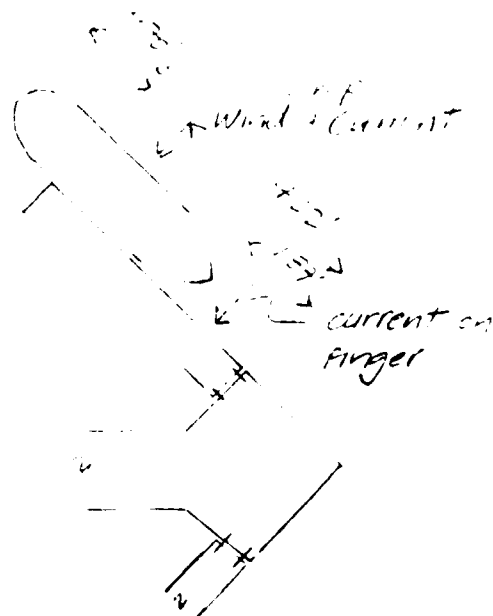
General Wind Loading

Wind speed to ship

Exposure factor  $C_{ex} = 1.0$

80'

Wind direction  $C_{fd} = 1.0$



Exposure Factor  $C_{ex} = 1.0$

$L = 470'$   
 $C_{ex} = 1.0$

Design for Transverse Current Loading:

Determine current forces by:

1. Approximate Method only

For future Navy Pier

470' x 60' x 35'

Approximate Method:

$$F_C = K \cdot V^2$$

$K = 0.5$  for curved surface ←

$$F_C = 15,000 (59)$$

$$V = 370/2' = 185 \text{ ft/s}$$

$$F_C = 573 \text{ k}$$

$$K = \text{avg. current velocity} = 59 \text{ ft/s}$$

using 3 values of  
area

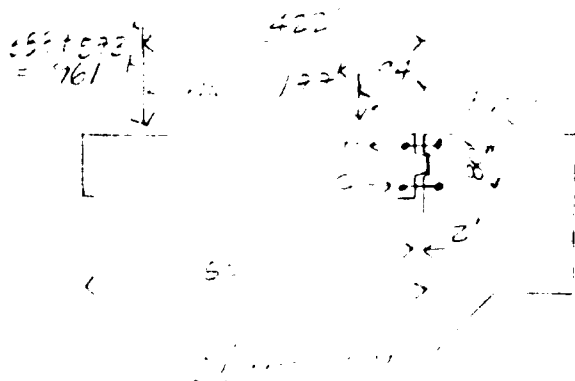
$$F_C = 15,000 (59)^2$$

$$= 1.7 \text{ k}$$

$$K = 15, A_C = 12' \times 7' = 84 \text{ ft}^2$$

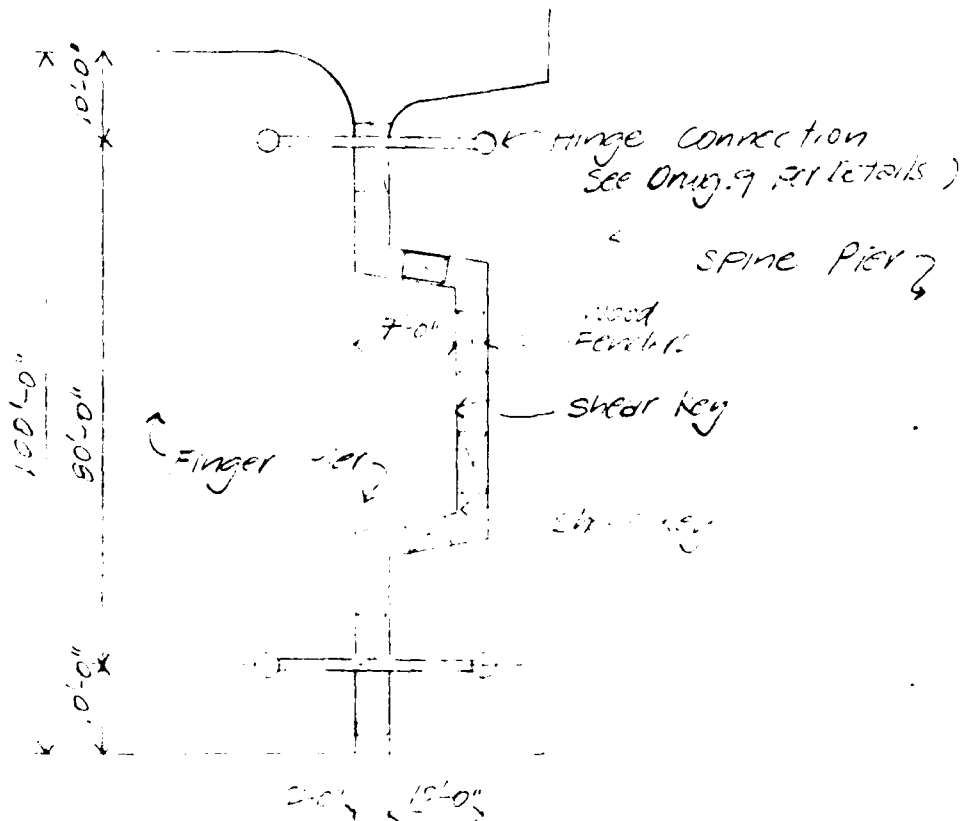
$$K = 5.9 \text{ ft/s}$$

Most loading case: All wind + current:

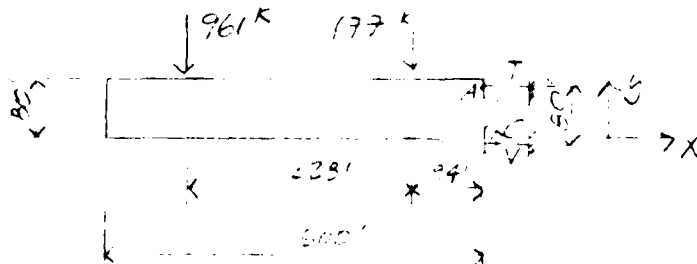


ASSUMPTIONS:

1. IF hinged connection
- Take tension and compression couple in link but between finger, SP-C piers.
- No energy is dissipated into water (no drag) All load goes to connections



Load Combination I : Wind + Current @ Service Conditions governs  
Finger Body Diagram



$$\sum F_y = 0$$

$$V = 961 + 177 = 1138K \text{ (INTO SHEAR KEY)}$$

$$\sum M_A = 0$$

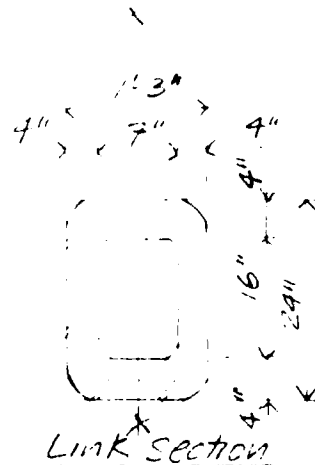
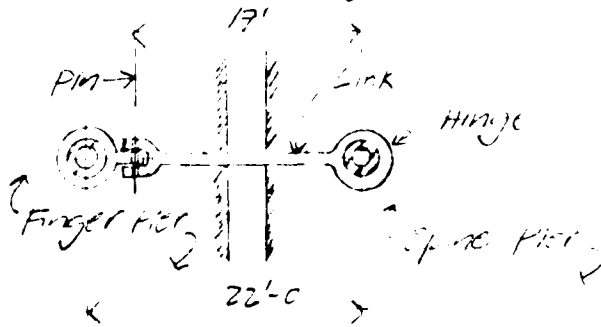
$$C = T = \frac{(961 \times 422' + 177 \times 94')}{80'} = 5277K$$

Design of Connection:

Link Design:

Compression add: 5250K ← ——— governs

CONT' LINK DESIGN



Hinge Connection Design

Use  $F_y = 50$  ksi steel

Rectangular Box Section

$$A_{req} = \frac{5280}{50} = 105.6$$

Try  $A = 248$  (see section above)

$$I_{xx} = \frac{24 \times 15^3}{12} - \frac{16 \times 7^3}{12} = 6292$$

$$r_g = \sqrt{\frac{6292}{248}} = 5$$

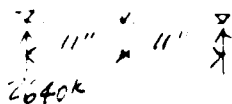
$$KL/r_g = 10 \times 17.12 / 5 = 40 < 300 \text{ satisfy Euler eqn.}$$

$F_{allowable} = 26$  ksi in compression

$$A_{req} = \frac{5280}{26 \text{ ksi}} = 203 < 248 \text{ OK}$$

Pin Design

$$P = 5280 \text{ K}$$



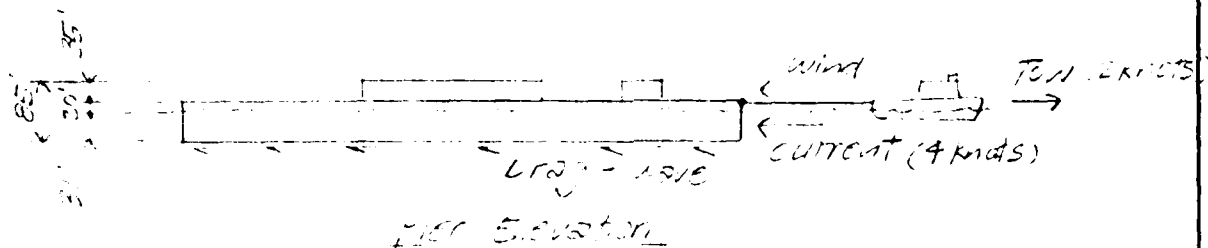
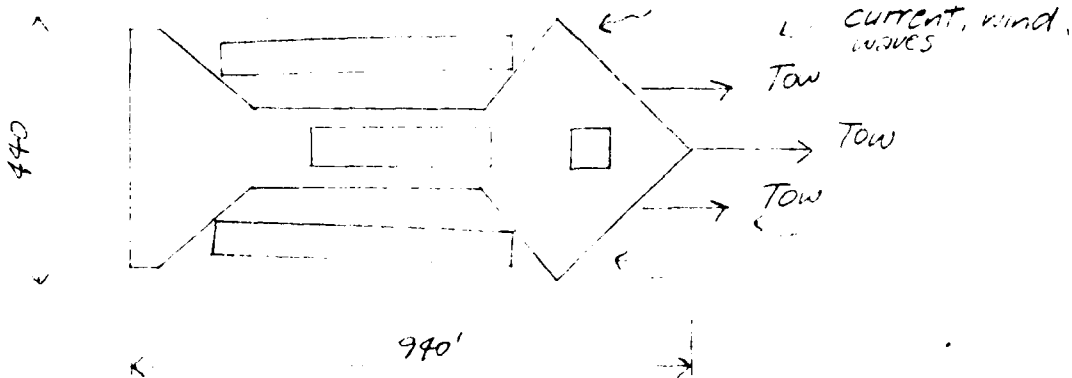
$$\text{REACTION} = 5280/2 = 2640 \text{ K}$$

$$F_y = 50 \text{ ksi (pin)}$$

$$A_{req} = \frac{2640}{50 \times 0.4} = 132 \text{ in}^2$$

$$\text{Use } 16" \phi \text{ PM, } A_{pin} = 200 \text{ in}^2$$

Total Resistance to Movement =



Environmental Loads

Current = 4 knots

Wind = 45 mph

Velocity = 6 knots

Wave making + Eddy

L Drag / Wind

Total Resistance =  $L = L_D + L_W + L_T + L_C$

(1) Friction Resistance - MAX. drag will occur when pier is moving at speed of 6 knots without any current or when a 4 knot current plus a towing speed of 4 knots occur.

MAX. Drag at 4 knot speed and 4 knots current see current resistance

$$\text{Reynold's Number} = \frac{VD\rho}{\mu} = \frac{7.7 \times 3.28 \times 440 \times 1.92}{8.0 \times 10^{-4}} = 3.9 \times 10^6 > 10^4$$



INTERNATIONAL  
STRUCTURAL ENGINEERING  
315 Bay St. San Francisco, Ca 94133

PROJECT: Navy Piers  
ITEM: Expeditionary Pier  
DESIGN: Resistance and Power  
DATE: 11-82 RM

SHEET: A-36  
OF:  
REVISION:

### Cont' Resistance to Movement

b) Extrapolate from Fig 35, Naval Architecture by Boxer

$$L = 990'$$

$$V = 6 \text{ knots}$$

$$R_{REP} \approx 10 \text{ tons} = 20^k$$

$$\begin{aligned} R_{T \text{ Total}} &= R_{REP} + R_{FF} \\ &= 20 + 6^k \\ &= 26^k \end{aligned}$$

←  $\Sigma K_r$

$$c) R_W = C_{yw} \cdot \frac{1}{2} \cdot \rho \cdot V^2 \cdot A_s$$

$$V_{air} = 40 \text{ mph} = 59 \text{ F/S}$$

$$C_{yw} = 1.0$$

$$\rho = 0.00237 \frac{\text{sl}}{\text{ft}^3} @ 65^\circ\text{F}$$

$$\begin{aligned} A_s &= 440' \times 31' + 120' \times 35' \\ &= 17840 \text{ ft}^2 \end{aligned}$$

$$R_{W_{EP}} = 1.0 \times \frac{1}{2} \times 0.00237 \times 59^2 \times 17840 = 74^k$$

$$\begin{aligned} R_{W \text{ Total}} &= R_{W_{EP}} + R_{W_{FF}} \\ &= 74 + 0 \\ &= 74^k \end{aligned}$$

←  $\Sigma K_W$

d) CURRENT RESISTANCE = USE 6 knots (positive velocity)

$$\begin{aligned} R_{CEP} &= R_{CEP} = C_D A_p \cdot \frac{\rho V^2}{2} \\ &= 1.2 \times 21030 \times 199 \times \frac{7.7^2}{2} \\ &= 1490^k \end{aligned}$$

$$A_p = 440' \times 31' + 240' \times 31' = 21030 \text{ ft}^2$$

$$V = 7.7 \text{ F/S}$$

$$C_D = 1.2 \text{ (rectangle)}$$

$$\begin{aligned} R_{CT \text{ Total}} &= R_{CEP} + R_{CFP} \\ &= 1490^k \end{aligned}$$

←  $\Sigma K_C$

$$\begin{aligned} \text{Total Resistance} &= 26^k + 74^k + 1490^k \\ &= 1590^k \end{aligned}$$

←  $\Sigma K_T$

### EFFECTIVE HORSE-POWER Required

$$E.H.P. = \frac{R_T \cdot V}{550}$$

$$V = 6 \text{ knots}$$

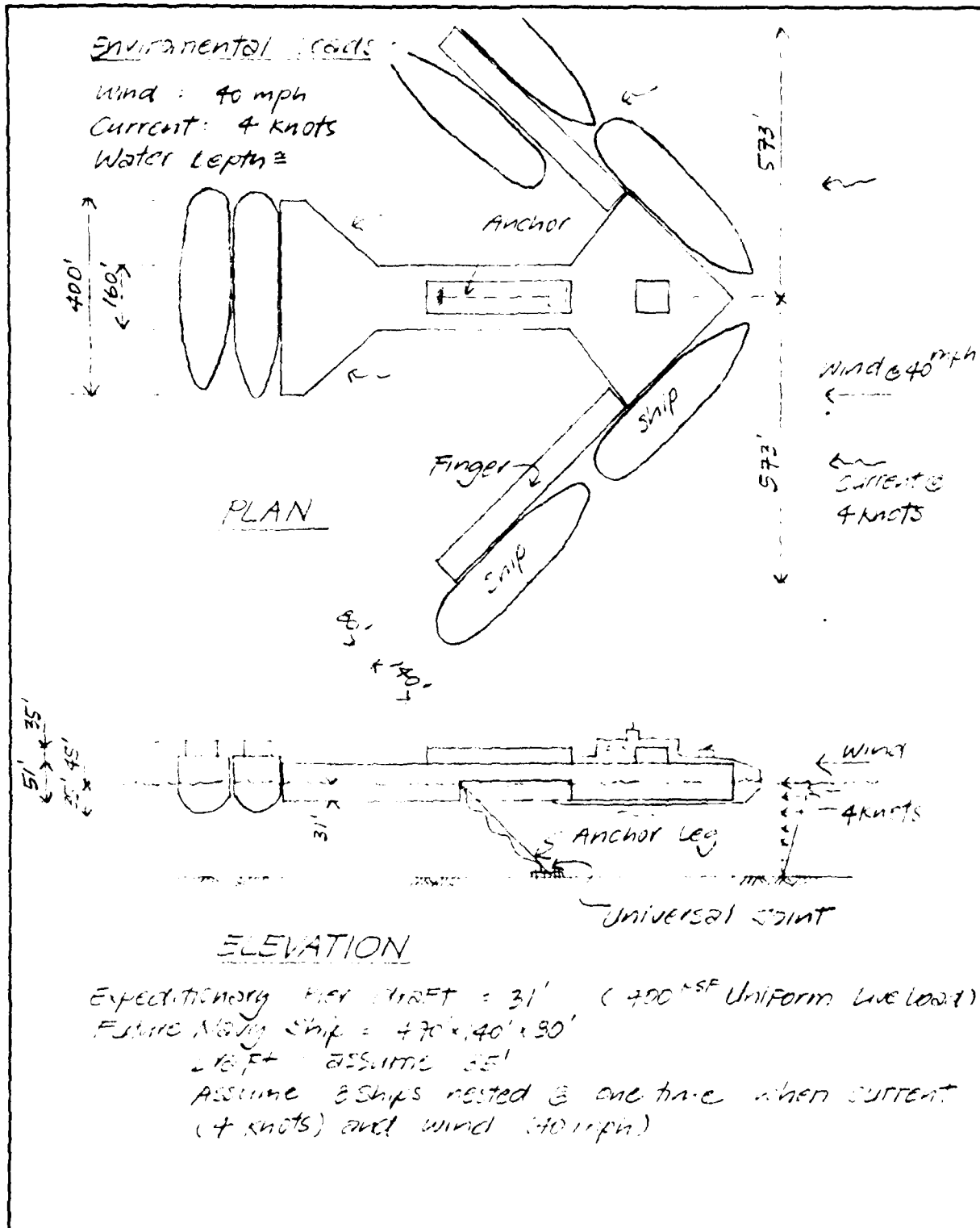
$$= \frac{1590 \times 6 \times 1.15}{550} = 29293 \times 1.2 = 35152 \text{ H.P.}$$

USE 3-12000 H.P. Tug boats ← # Tug boats req'd.  
or 2-18000 H.P. Tug boat

**TYIN**  
INTERNATIONAL  
STRUCTURAL ENGINEERING  
315 Bay St. San Francisco, Ca 94133

PROJECT: Navy Piers  
ITEM: Expeditionary Pier  
DESIGN: Anchor Leg  
DATE: 11/92 KM

SHEET:  
A-37  
OF  
REVISION:



Wind Load :

$$F_w = C_{yw} \cdot P_w V_w^2 A_s$$

$$C_{yw} = 1.0 \quad \text{Wind @ } 90^\circ$$

$$P_w = 0.00237 \frac{\text{lb} \cdot \text{sec}^2}{\text{ft}^4} @ 68^\circ \text{F}$$

$$V_w = 40 \text{ mph} = 59 \text{ F/s}$$

$$\begin{aligned} A_{s \text{ total}} &= A_{s \text{ ship}} + A_{s \text{ pier}} \\ &= 2 \times 470' \times 45' \cos 45^\circ + 470' \times 45' + 17340' \text{ FROM PREVIOUS CALCS} \\ &= 128722 \text{ ft}^2 \end{aligned}$$

$$\begin{aligned} F_w &= 1.0 \times 1/2 \times 0.00237 \times 59^2 \times 128722 \text{ ft}^2 \\ &= 531 \text{ K} \end{aligned}$$

Current Load :

Approximate Method:

$$F_c = K A_c V_c^2$$

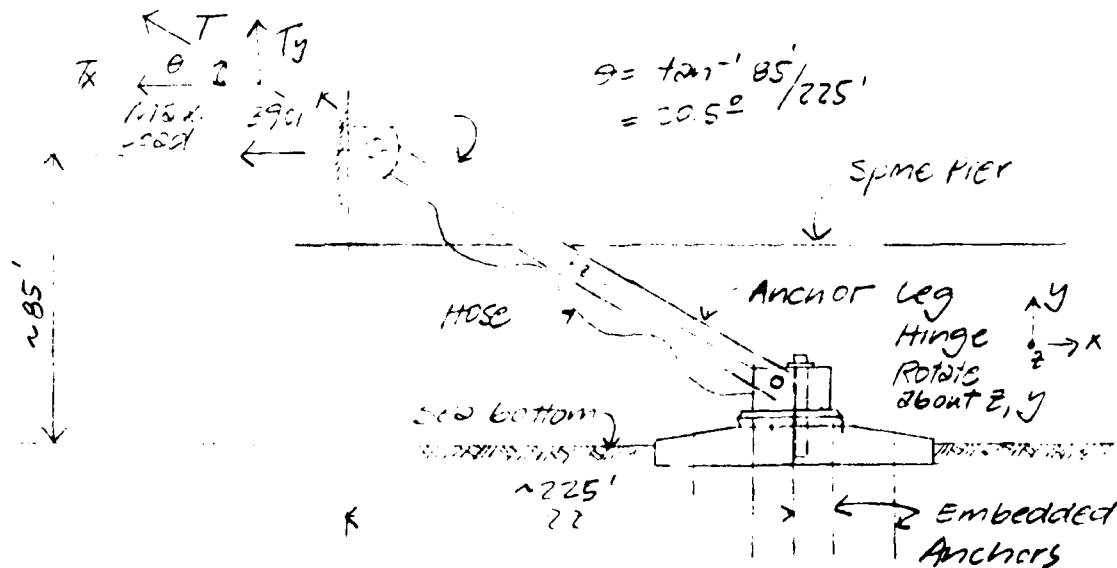
$$\begin{aligned} &= 1.0 \times 107321 \times 5.1^2 \\ &= 2820 \text{ K} \end{aligned}$$

$$K = 2 \quad \text{2UG}$$

$$\begin{aligned} A_{s \text{ total}} &= A_{s \text{ ship}} + A_{s \text{ pier}} \\ &= 6 \times 470' \times 35' \cos 45^\circ \\ &\quad + 470' \times 35' + 440' \times 31' + 240' \times 31' \\ &= 107321 \text{ ft}^2 \end{aligned}$$

$$K_c = 4 \text{ knots} = 5.1 \text{ F/s}$$

$$\begin{aligned} \text{TOTAL LOAD} &= 531 + 2820 \\ &= 3351 \text{ K} \end{aligned}$$





STRUCTURAL ENGINEERING  
315 Bay St., San Francisco, Ca 94133

PROJECT: Navy Piers  
ITEM: Expeditionary Pier  
DESIGN: Anchor Leg Design  
DATE: 11/82 RM

SHEET: A-39  
OF  
REVISION:

Cont' Anchor Leg Loading:

$$T_y = T_x \tan \theta$$

$$= 3901 \times \tan 20.6^\circ$$

$$= 1474 \text{ k}$$

$$T = \sqrt{T_x^2 + T_y^2} = \sqrt{3901^2 + 1474^2}$$

$$= 4170 \text{ k}$$

Leg Design:  $F_y = 50 \text{ ksi}$

a) Tension:  $A_{leg} = \frac{4170}{50 \times 0.6}$   
 $= 139 \text{ in}^2$   
 Use avg.  $A = 200 \text{ in}^2$

b) Bending:

$$\text{Lin weight} = 100 \times 1.49$$

$$= 149 \text{ k/ft}$$

$$M_{max} = \frac{wL^2}{8} = \frac{149 \times 225^2}{8}$$

$$= 4601 \text{ k-ft}$$

$$S_{x-x} \text{ req} = \frac{4601 \times 12}{150 \times 0.66}$$

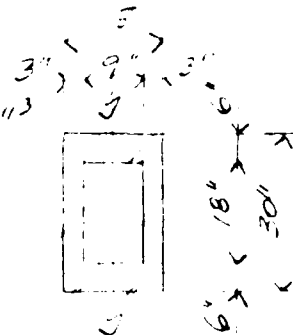
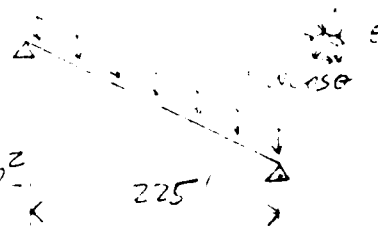
$$= 1672 \text{ in}^3$$

$$S_{x-x} = \frac{15 \times 50^3 \times 3 \times 5^3}{6 \times 30} = 1900 \text{ in}^3 > 1672 \text{ in}^3$$

OK.

$$A_{prov} = 288 \text{ in}^2 > 139 \text{ in}^2 \text{ req.}$$

✓



Pin Design:

$$\text{Shear } V = 4601/2 = 2300 \text{ k}$$

$$A_{req} = \frac{2300}{0.4 \times 0.4} = 115 \text{ in}^2$$

USE 15"  $\phi$  PIN

Leg X-Section  
@ midspan

PROJECT NO. \_\_\_\_\_

DESIGN \_\_\_\_\_

DRAFTING \_\_\_\_\_

D-963 DESTROYER,  
MISSILE CRUISER →

400'-0"

160'-0"

SHIP

FINGER PIER

RETRACTED POSITION  
FOR TOWING

500'-0"

11 @ 60' = 660'-0"

PLAN

1" = 200'-0"

WATER, FUEL POWER PLANT  
STEAM PLANT, WORKSHOP

VARIES  
34' 13' 35'

13'

PROFILE

1" = 200'-0"

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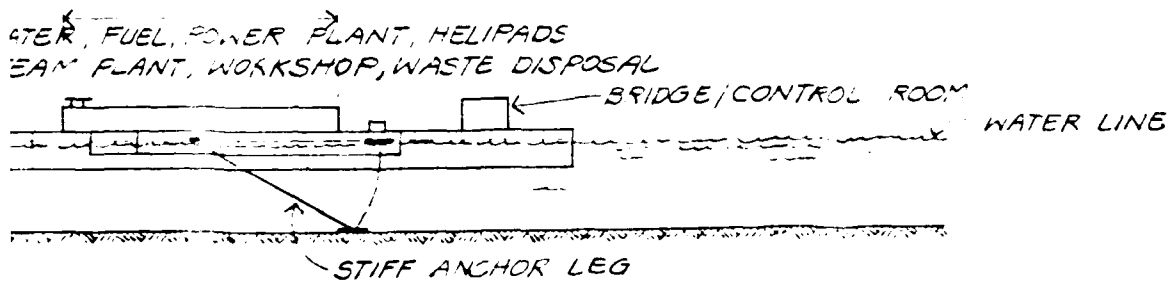
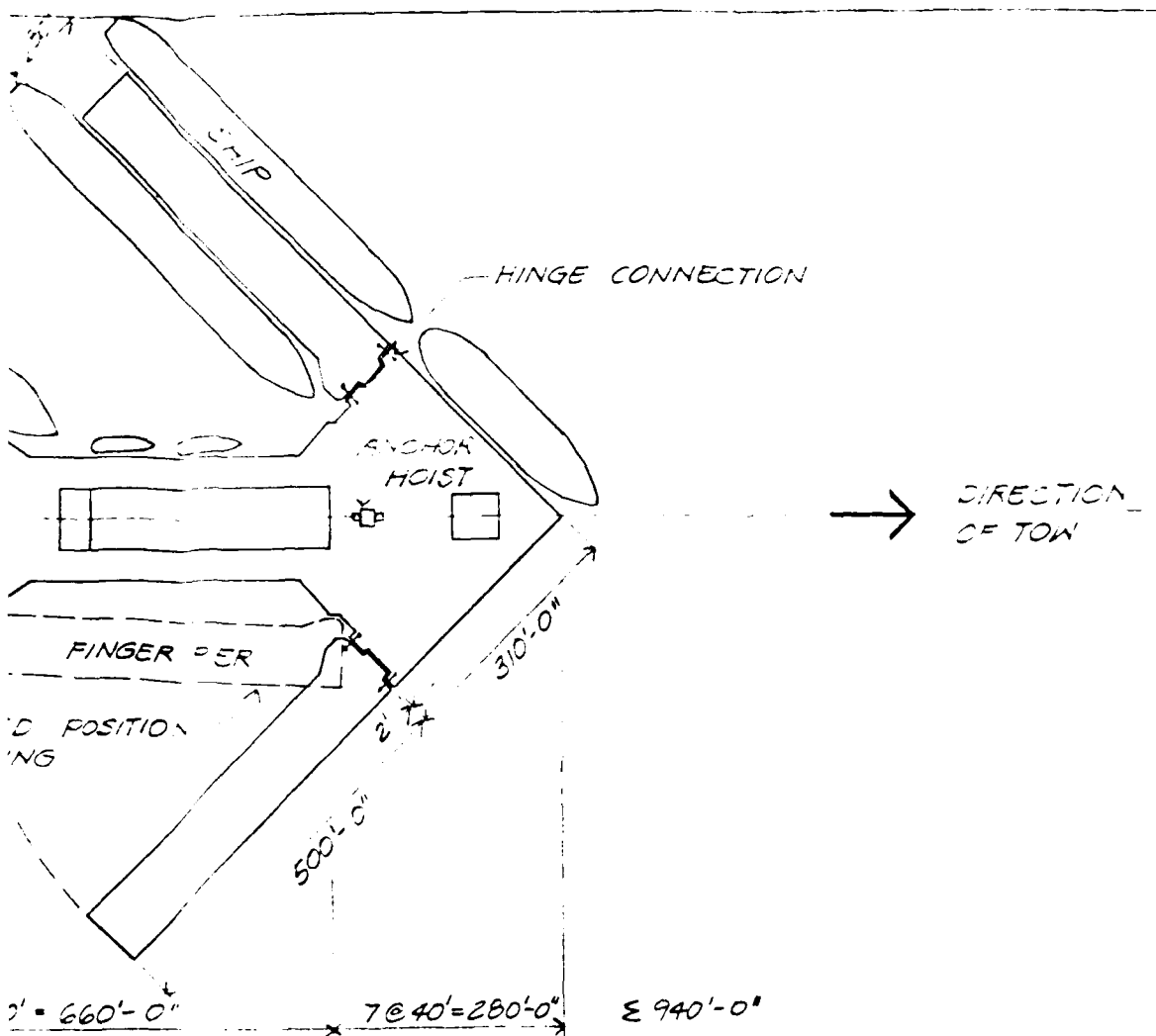
315 Bay St., San Francisco, Ca 94133 Tel (415) 882-1080

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100%

Date

Dec 82



NO	REVISION	DATE

Issued For	Date	By
100%	Dec, 82	RM

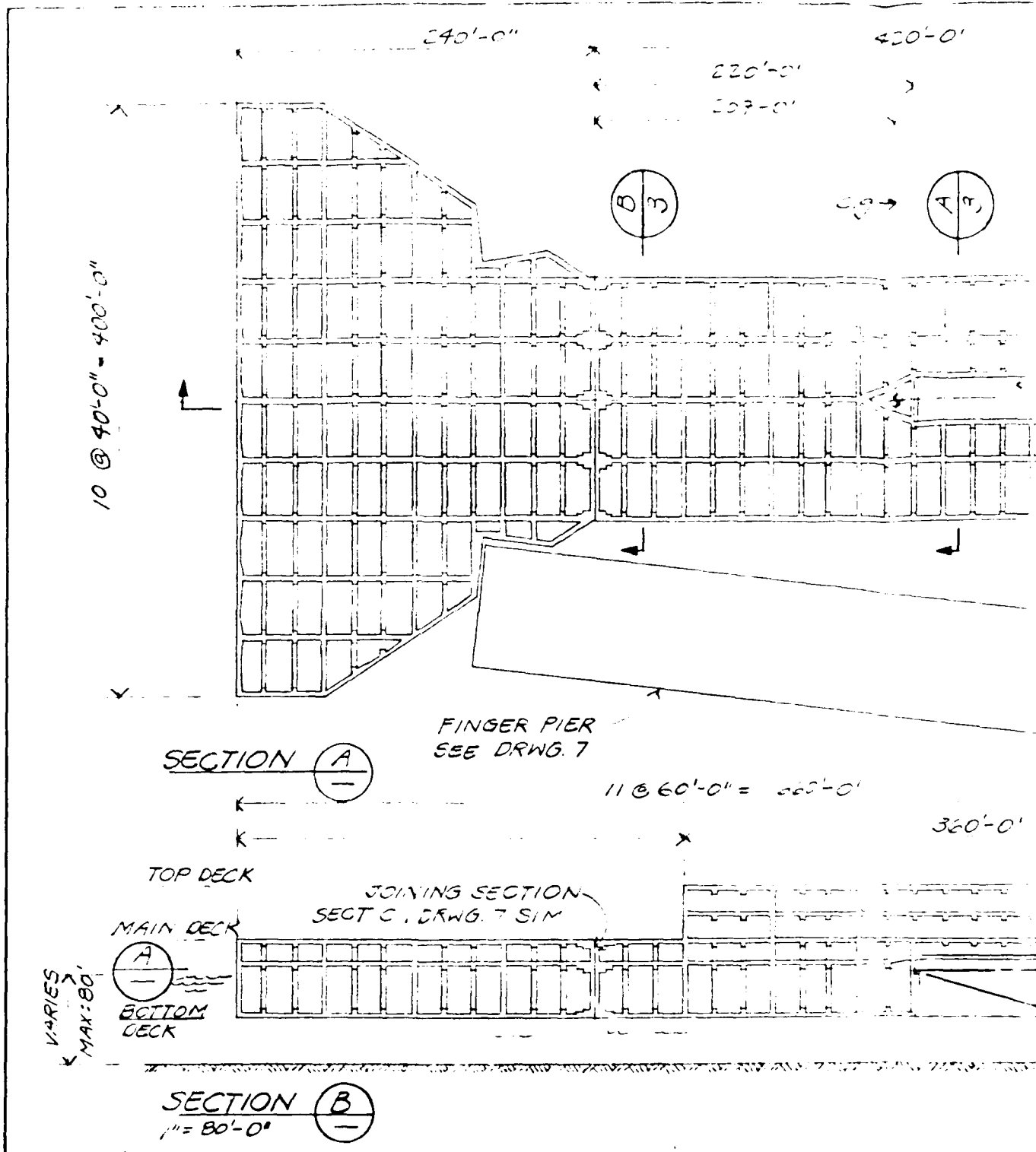
SHEET TITLE	SCHEME A
PROJECT	EXPEDITIONARY PIER

SHEET NO	1
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DRAFTING

DESIGN

PROJECT NO



**TYLIN**

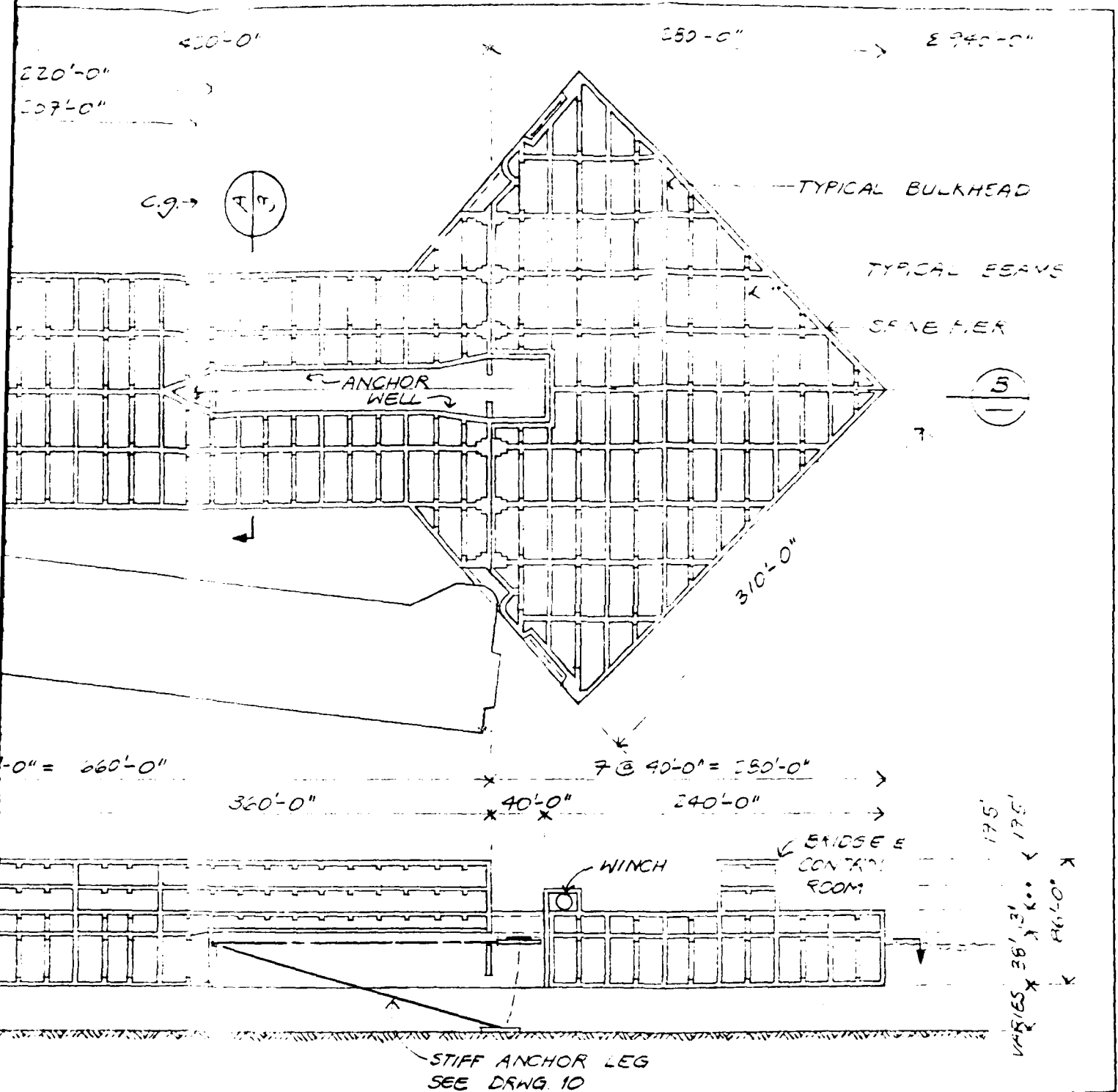
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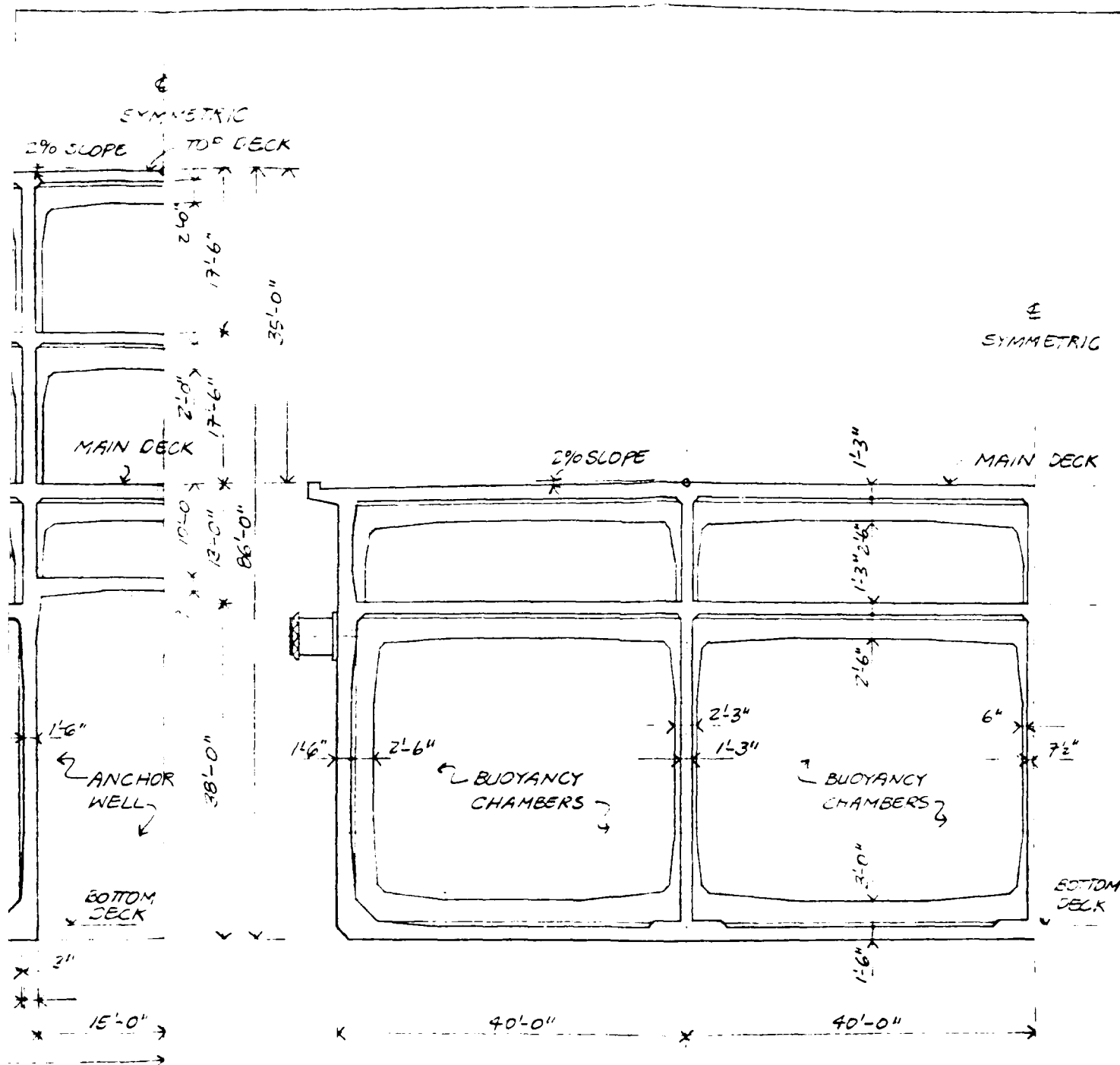
225 E



Issued For			Date	By	SHEET TITLE	REVISION	DATE
100%			22, 82	RM	SPINE LONGITUDINAL SECTIONS - SCHEME A		
PROJECT					EXPEDITIONARY PIER		
					SHEET NO 2		



Issued For	Date
100%	Mar 83

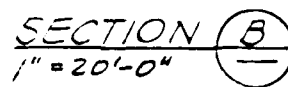
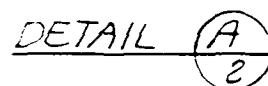


SECTION **B**  
 $\frac{3}{4}" = 1'-0"$   
**2**

NO. REVISION DATE

Issued For	Date	By	SHEET TITLE	SHEET NO.
100%	SEP 83	A.M.	SPINE PIER CROSS SECTION-SCHEME A	3
			PROJECT	
			EXPEDITIONARY PIER	

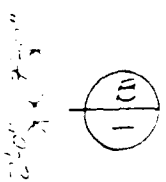
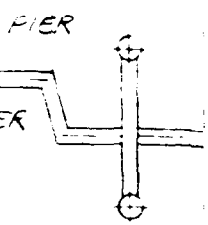
PROJECT NO



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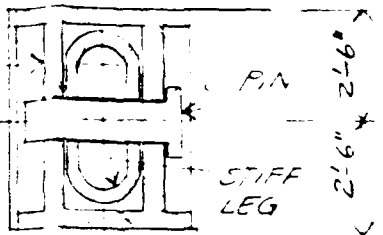
Yours, E

2'-0" 8' 10' 10'



BEARING AND TENSION PL.

2'-6"



PIA

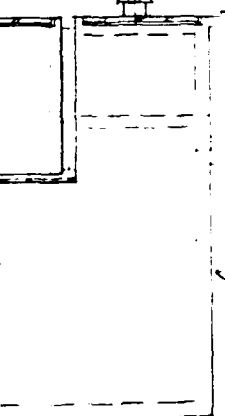
STIFF LEG

ANCHOR WELL

SECTION C  
10

PLATE

HINGE CONNECTION  
SEE LHWG 9

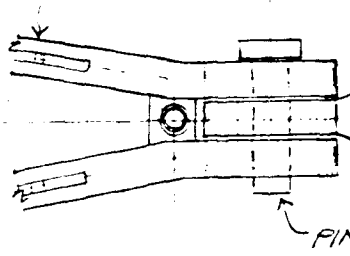


WATER LINE

FENDER

SPINE PIER

STIFF LEG ANCHOR



PIN

CENTERLINE OF ANCHOR HINGE

OUTER HOLLOW TUBE

INNER HOLLOW TUBE

2'-6" 5'-0"

CENTERLINE OF HOSE OPENING

SECTION D  
4" = 1'-0" 10

Issued For	Date	By	SHEET TITLE	REVISION	DATE	SHEET N°
100%	Jan. 83	KM	SPINE PIER DETAILS			4
			PROJECT			
			EXPEDITIONARY PIER			

DRAFTING

DESIGN

PROJECT NO

D-965 DESTROYER  
MISSILE CRUISER

160'-0"

SHIP

FINGER PIER

RETRACTED POSITION  
FOR TOWING

500'-0"

11 @ 60' = 660'-0"

PLAN

1" = 200'-0"

WATER, FUEL, POWER PLANT  
STEAM PLANT, WORKSHOP,

17'-35"

13'

VARIES 34'

PROFILE

1" = 200'-0"

**TYLIN**

INTERNATIONAL  
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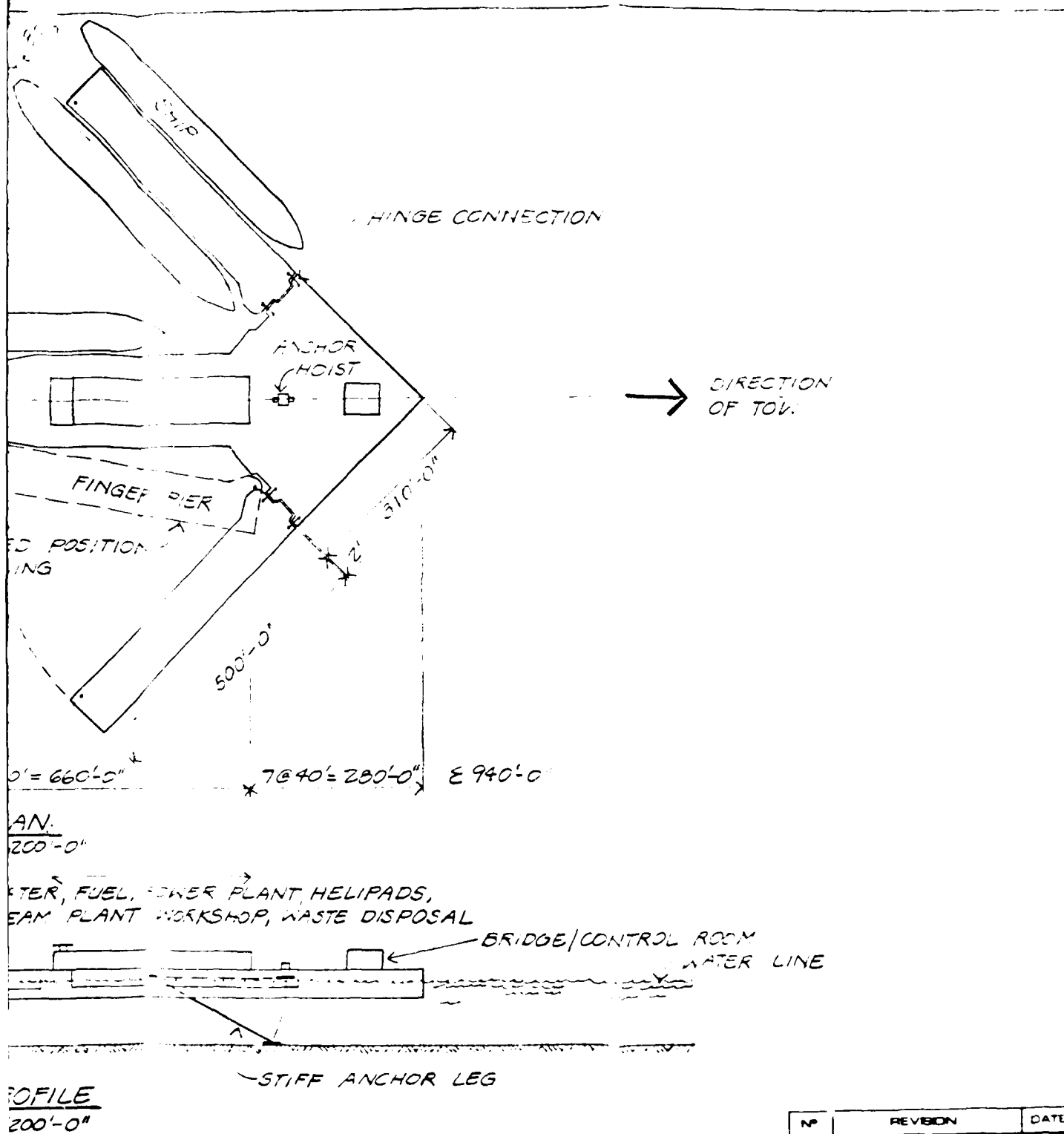
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50%

Date

5/2/75



Issued For	Date	By	SHEET TITLE	SHEET NO.
100%	JAN 63	RM	SCHEME B	5
			PROJECT	
			EXPEDITIONARY PIER	

DRAFTING

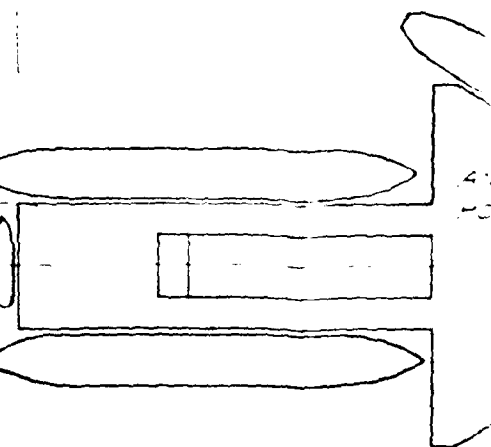
DESIGN

PROJECT NO

D-963 DESTROYER,  
MISSILE CRUISER

160'-0"

540'-0"



113.60 = 360'-0"

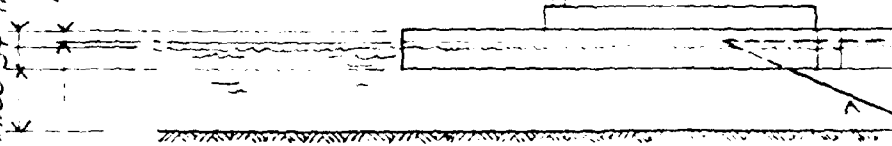
940'-0"

PLAN

WATER FUEL, POWER  
HELIPAD, STEAM PLANT  
WORKSHOP, WASTE DIS

VARIES 34' 17'

13'



PROFILE

1"=200'-0"

**TYLIN**

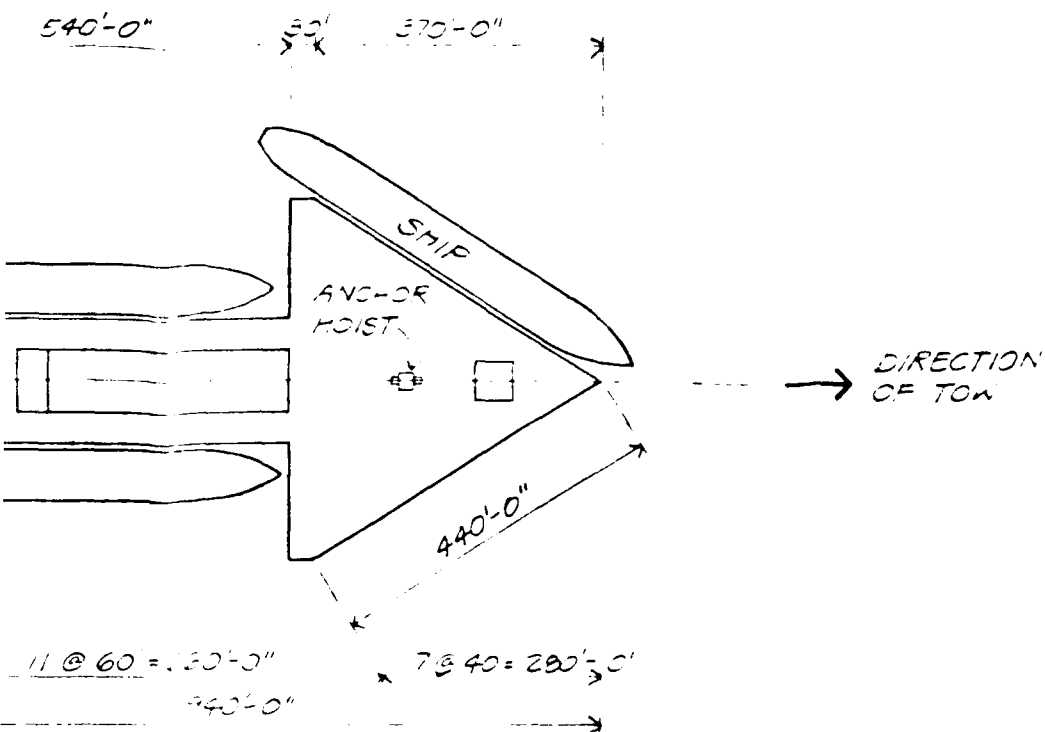
INTERNATIONAL  
STRUCTURAL ENGINEERING  
315 Bay St., San Francisco, Ca 94133 Tel (415) 982-1050

Issued For

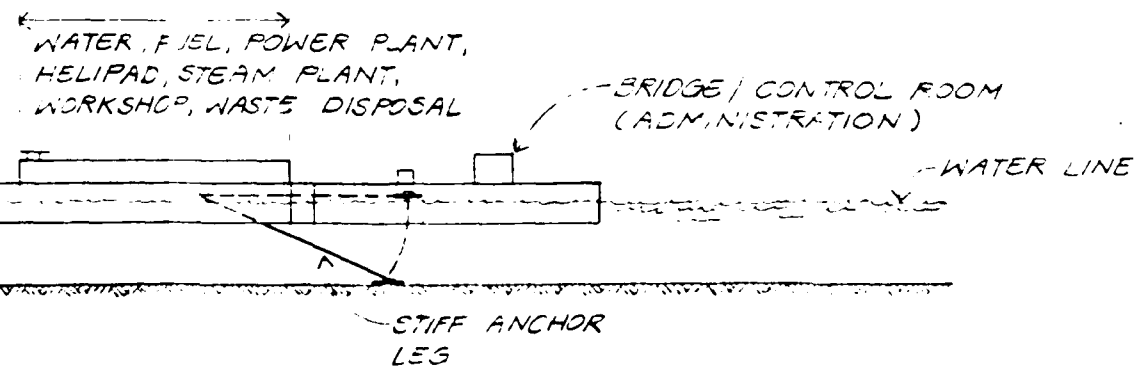
100%

Date

000 90



PLAN



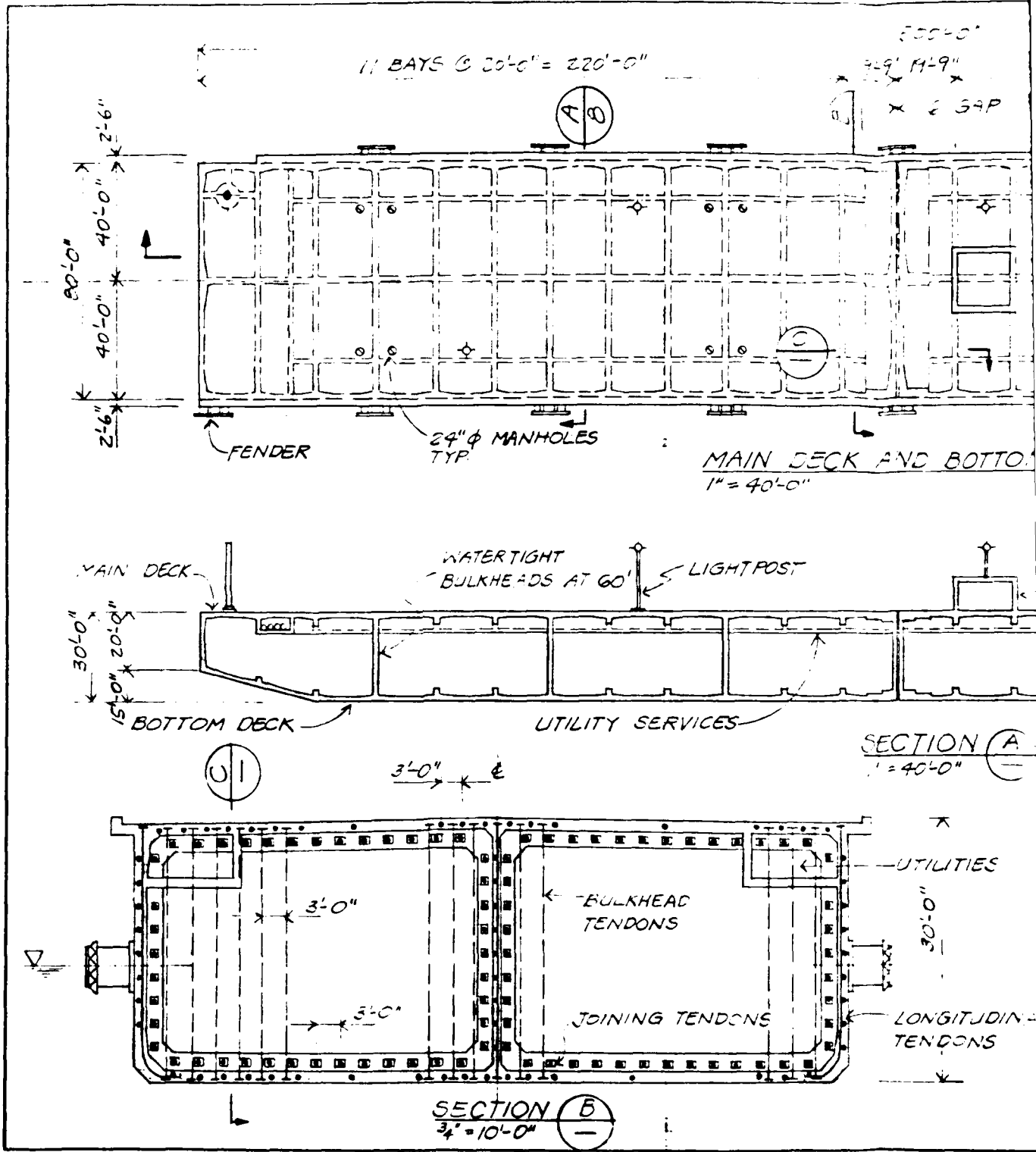
PROFILE  
1"=200'-0"

Issued For			REVISION		DATE
100%	Dec. 82	KM			
SHEET TITLE			PROJECT		SHEET N°
SCHEME C			EXPEDITIONARY PIER		6

DRAFTING

DESIGN

PROJECT NO



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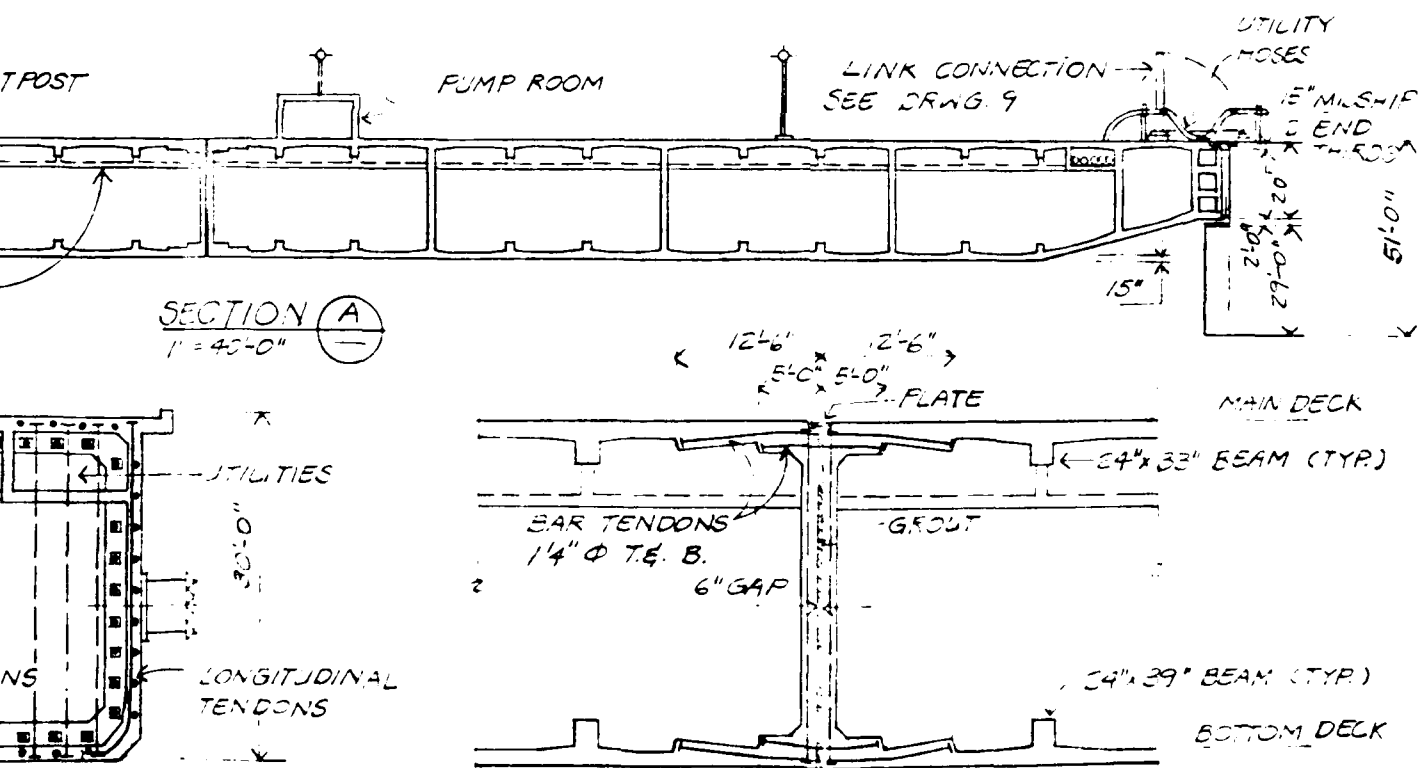
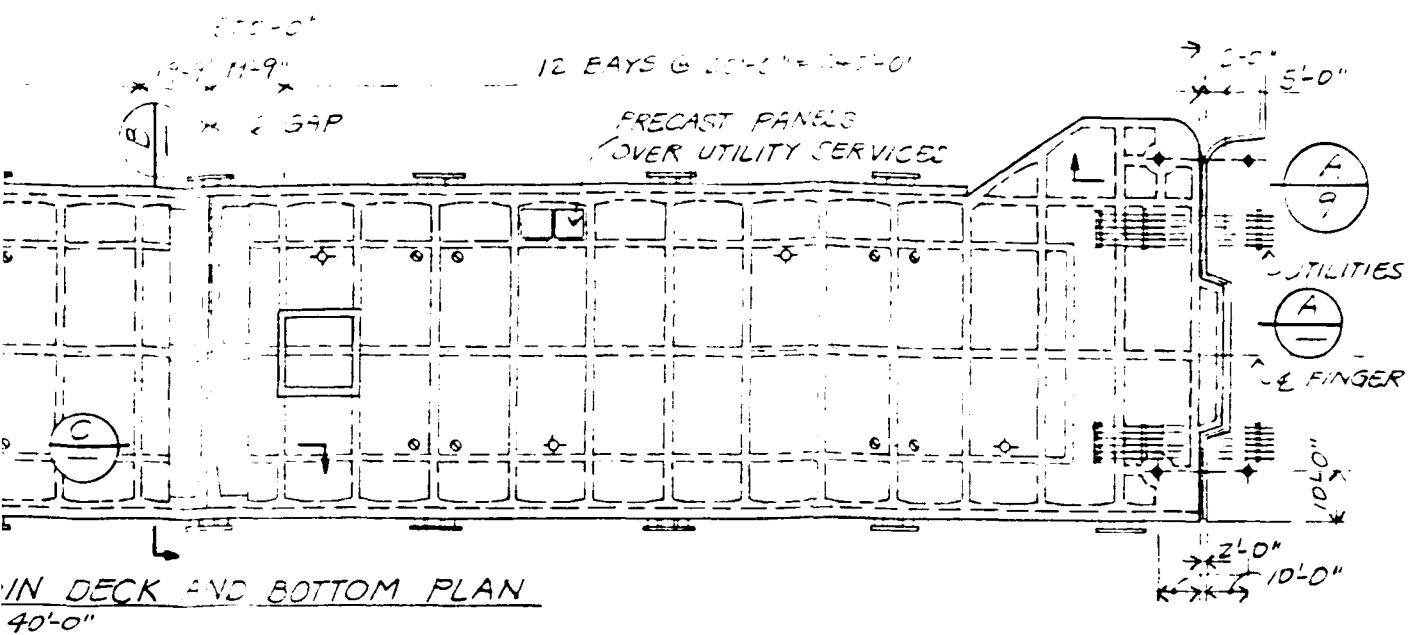
315 Bay St., San Francisco, Ca 94133 Tel (415) 982-1080

Issued For

100%

Date

Dec. 82

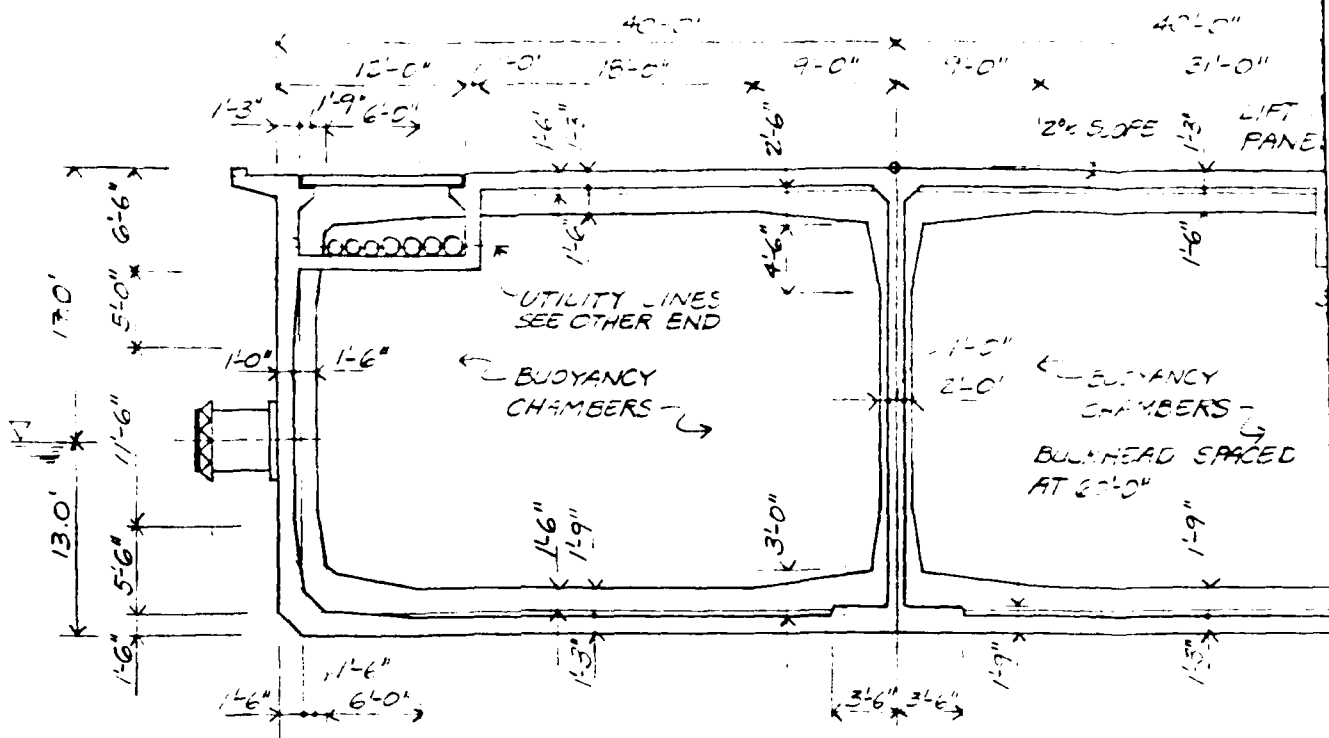


COUNTING SECTION			N°		REVISION	DATE
34" = 10'-0"						
Issued For	Date	By	SHEET TITLE			SHEET N°
100%	Dec. 82	RM	FINGER PIER SECTIONS & DETAILS			7
			PROJECT			
			EXPEDITIONARY PIER			

PROJECT NO. \_\_\_\_\_

DESIGN \_\_\_\_\_

DRAFTING \_\_\_\_\_



TYPICAL FINGER CROSS SECTION (A)  
1" = 10'-0" 7

**TYL**

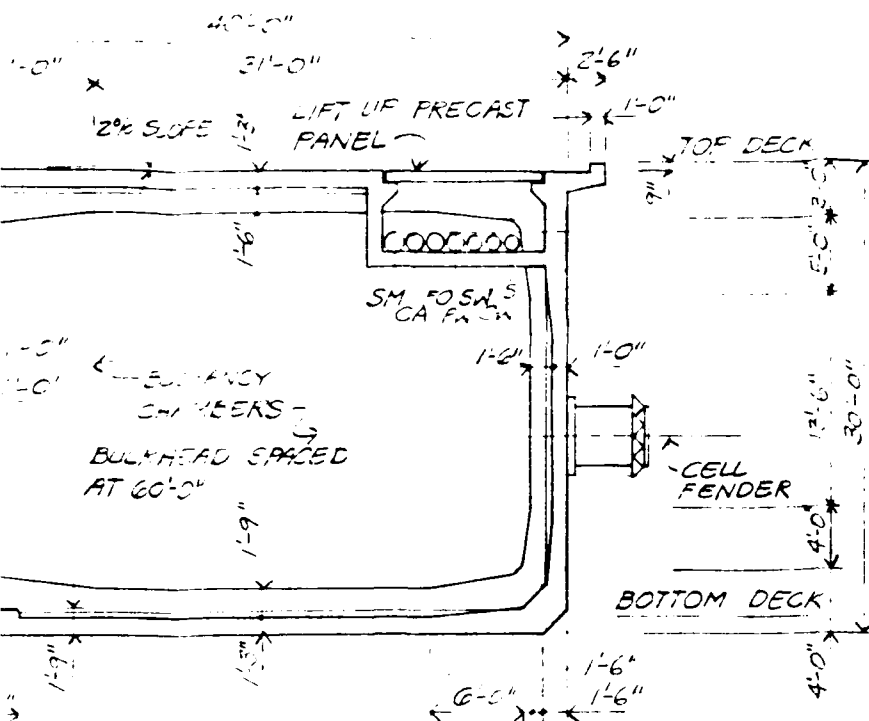
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Date

Dec, 82



# LEGEND:

SM	STEAM
CA	COMPRESSED AIR
FO	FUEL OIL
PW	POTABLE WATER
SW	SALT WATER
OW	OIL WASTE
S	SEWAGE

CROSS SECTION

A  
7

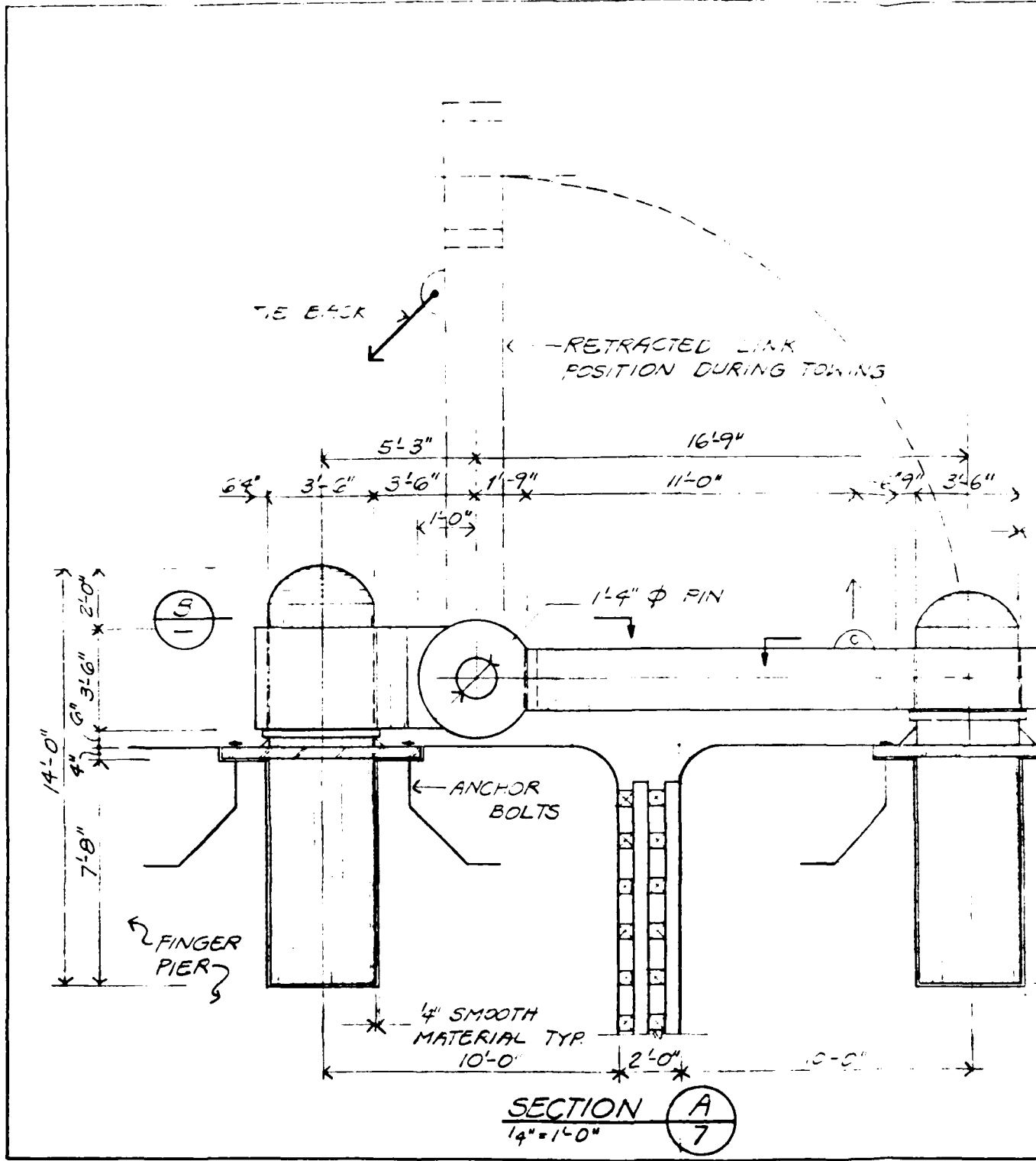
Nº	REVISION	DATE
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Issued For	Date	By	SHEET TITLE	SHEET Nº
100%	DEC, 82	RM	FINGER DETAILS	8
			PROJECT	
			EXPEDITIONARY PIER	

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DESIGN

PROJECT NO



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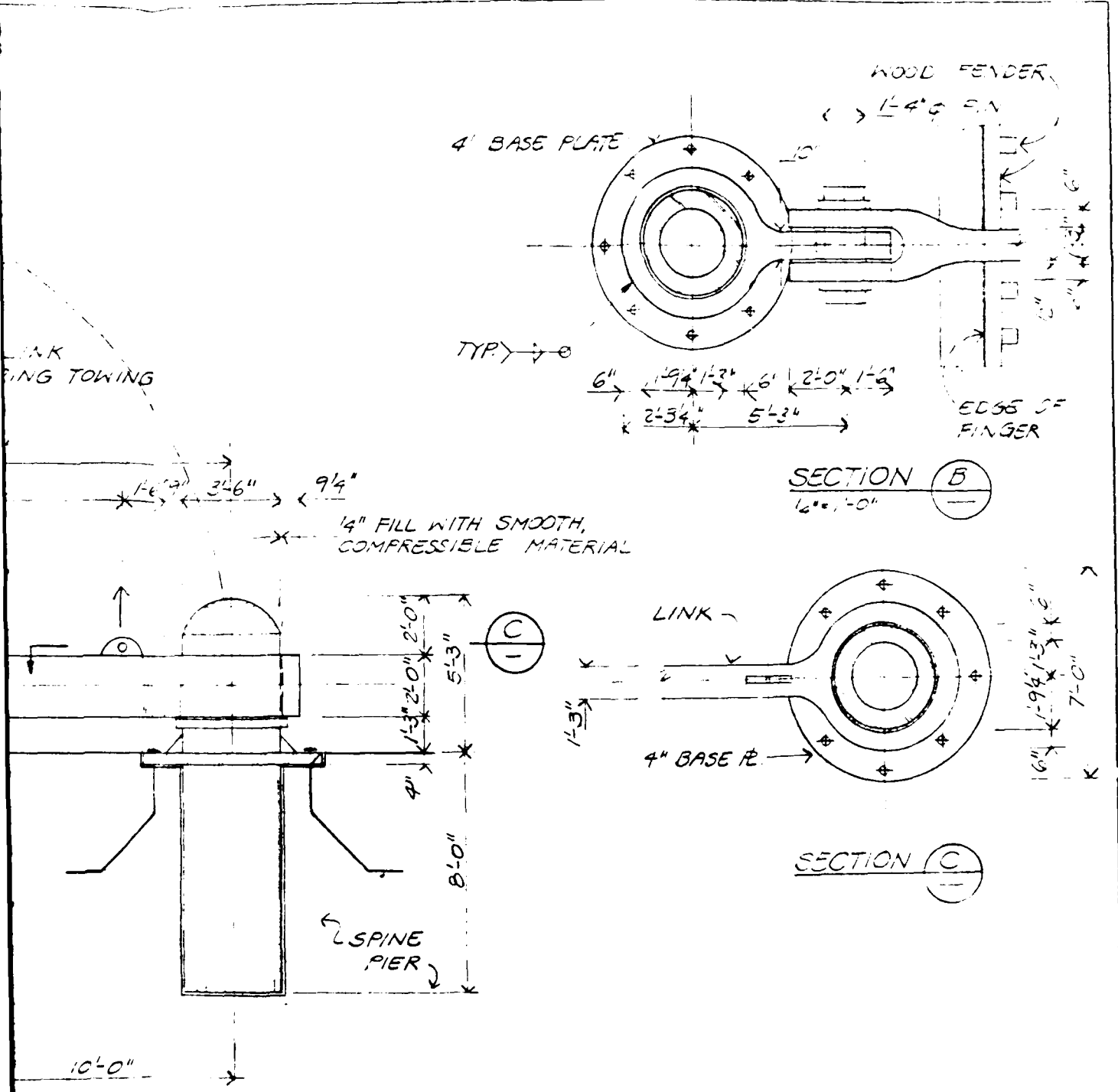
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Date

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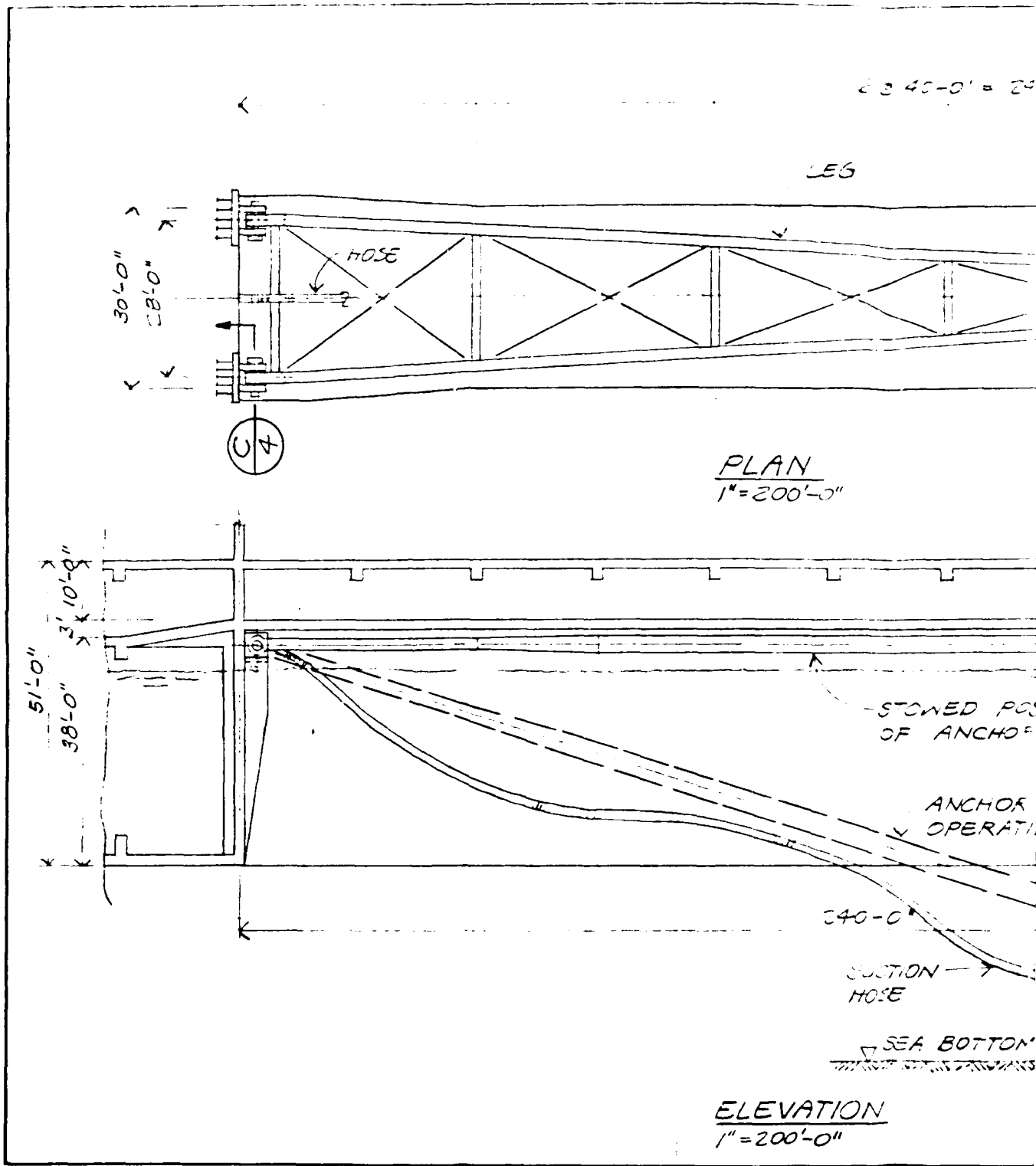


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100%	2-1-55	KM			
SHEET TITLE			SHEET NO.		
PROJECT			9		
HINGE CONNECTION FINGER/SPINE					
EXPEDITIONARY PIER					

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DESIGN

PROJECT NO.



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100%

Date

Jan. 5,

60' 40" - 0' = 240' - 0"

LEG

40' 0" PER CENTERLINE

EDGE OF ANCHOR WELL

PLAN  
"=200'-0"

ANCHOR HOIST

MAIN DECK

LOWER DECK

WATER LEVEL

STOWED POSITION OF ANCHOR BOOM

ANCHOR BOOM IN OPERATING POSITION

DRAFT=24'-0"  
VARIES

240'-0"

SUCTION HOSE

SEA BOTTOM

PROPELLANT EMBEDDED ANCHORS

①  
4

ELEVATION  
"=200'-0"

NO REVISION DATE

Issued For	Date	By
100%	Jan. 63	RM

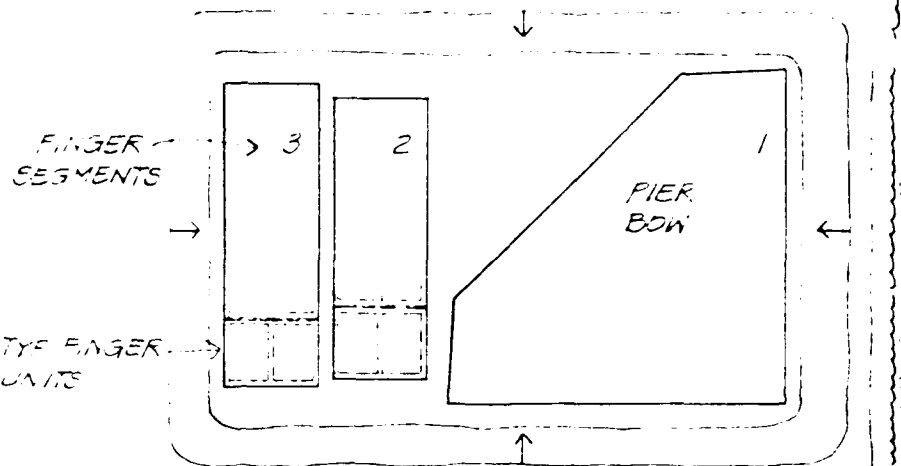
SHEET TITLE	STIFF LEG ANCHOR
PROJECT	EXPEDITIONARY PIER

SHEET NO	10
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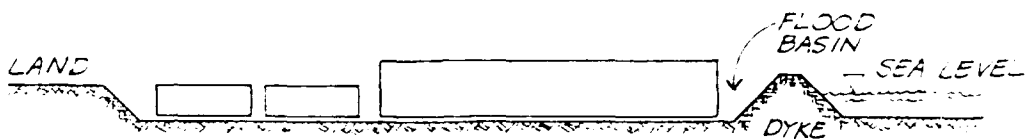
DRAFTING

DESIGN

PROJECT NO.

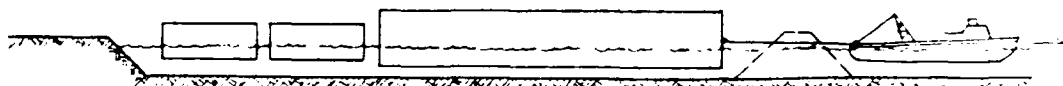


FLOOD BASIN PLAN  
3/4" = 10'-0" TYP.



① CONSTRUCTION IN FLOOD BASIN

- a) BUILD ONE 520'x320' BASIN
- b) JOINT PRECAST UNITS OF PIER BOW (1) AND FINGER (2,3) BY POSTENSIONING
- c) INSTALL UTILITY SYSTEM



② TOW TO ASSEMBLY SITE

- a) REMOVE DYKE TO FLOAT UNITS
- b) TOW TO ASSEMBLY AND FINISHING SITE

**TYLON**

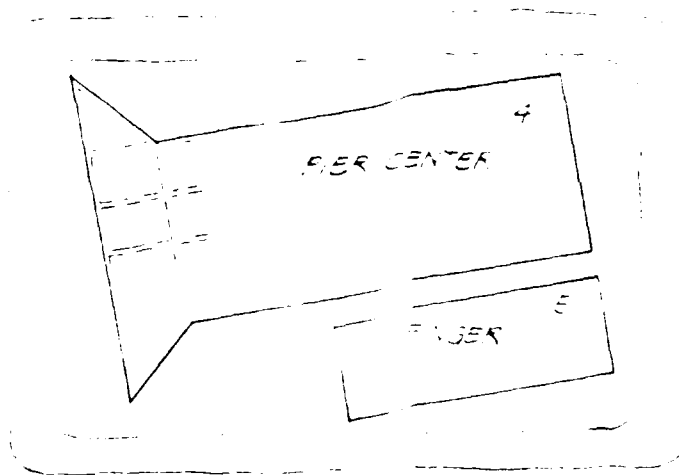
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Issued For

Date

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Dec, 82

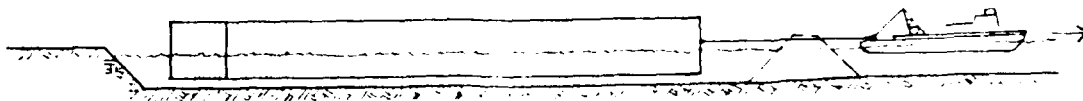


FLOOD BASIN PLAN



③ CONSTRUCTION IN FLOOD BASIN

- a) REBUILD DYKE
- b) PUMP WATER OUT
- c) JOINT PRECAST UNITS OF PIER CENTER (4) AND FINGER SEGMENT (5) BY POSTENSIONING
- d) INSTALL UTILITY SYSTEM



④ TOW TO ASSEMBLY SITE

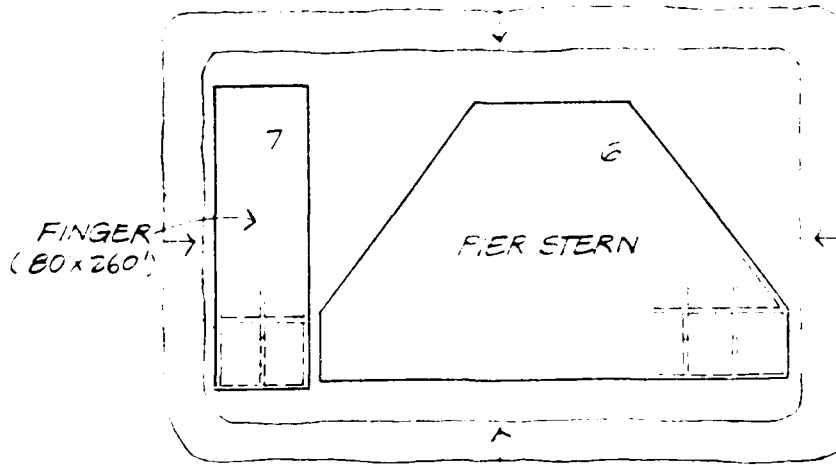
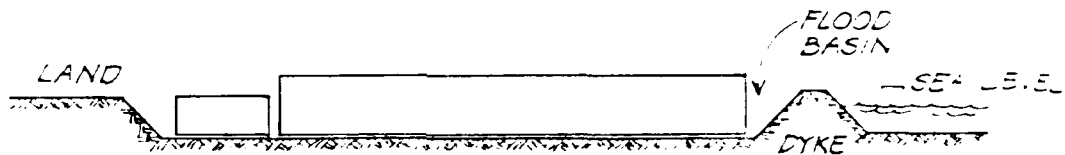
- a) REPEAT STEP 2

Issued For			SHEET TITLE		SHEET NO	
Date			PROJECT		11	
By			EXPEDITIONARY PIER			
%						
DEC, 82						
RM						

DRAFTING

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PROJECT NO.

FLOOD BASIN PLAN

⑤ CONSTRUCTION IN FLOOD BASIN

- a) REPEAT STEP 3a, 3b
- b) JOINT PRECAST UNITS OF PIER STERN (6) AND FINGER (7) BY POSTENSIONING
- c) INSTALL UTILITY SYSTEM
- d) REPEAT STEP 2

**TYIN**

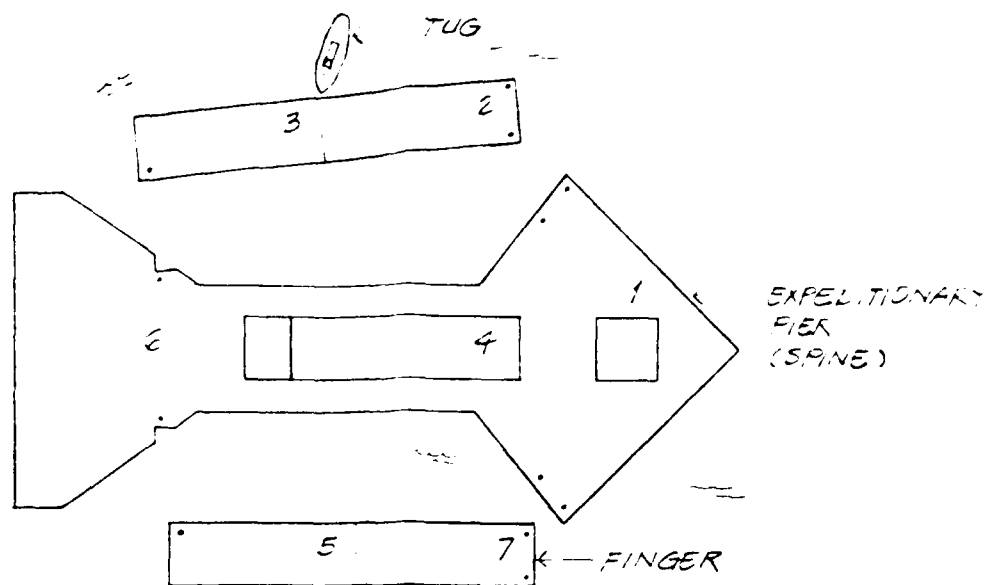
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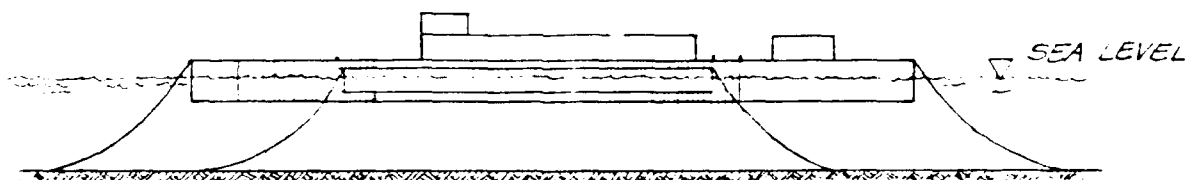
100%

Date

DEC 6



ASSEMBLY SITE PLAN



## 6 ASSEMBLY PIER SEGMENTS

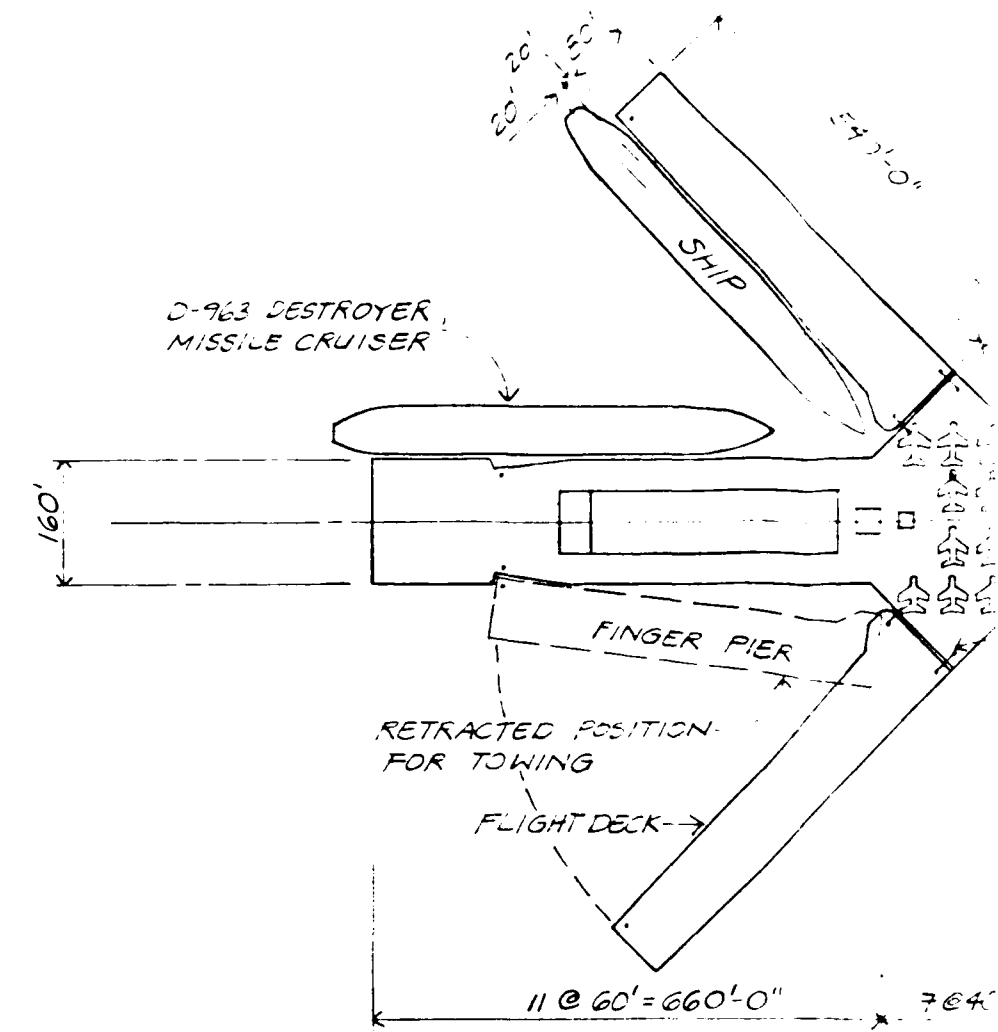
- a) JOIN EXPEDITIONARY PIER (1,4,6) AND FINGERS (2,3 FIRST THEN 5,7) BY POSTENSIONING
- b) TUG FINGERS INTO SPINE
- c) COMPLETE CONSTRUCTION
- d) HOOK UP UTILITY LINES
- e) READY FOR USE

Issued For			Date	By	SHEET TITLE		REVISION		DATE
100%			DEC 82	RM	FLOOD BASIN CONSTRUCTION METHOD				
					PROJECT				SHEET N°
					EXPEDITIONARY PIER				12

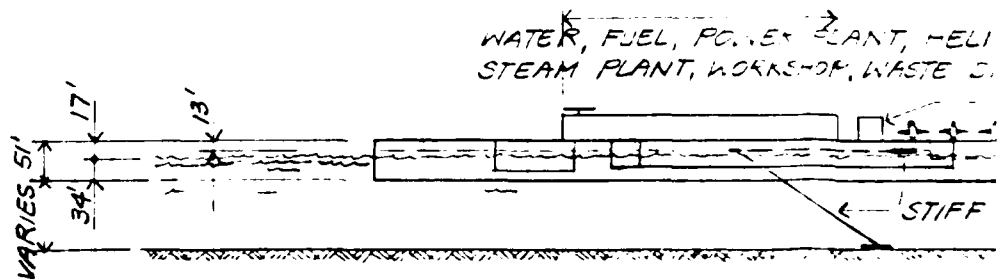
PROJECT N9 \_\_\_\_\_ DRAFTING

DESIGN

PROJECT N9



PLAN



PROFILE  
1" = 200'

**TYIN**

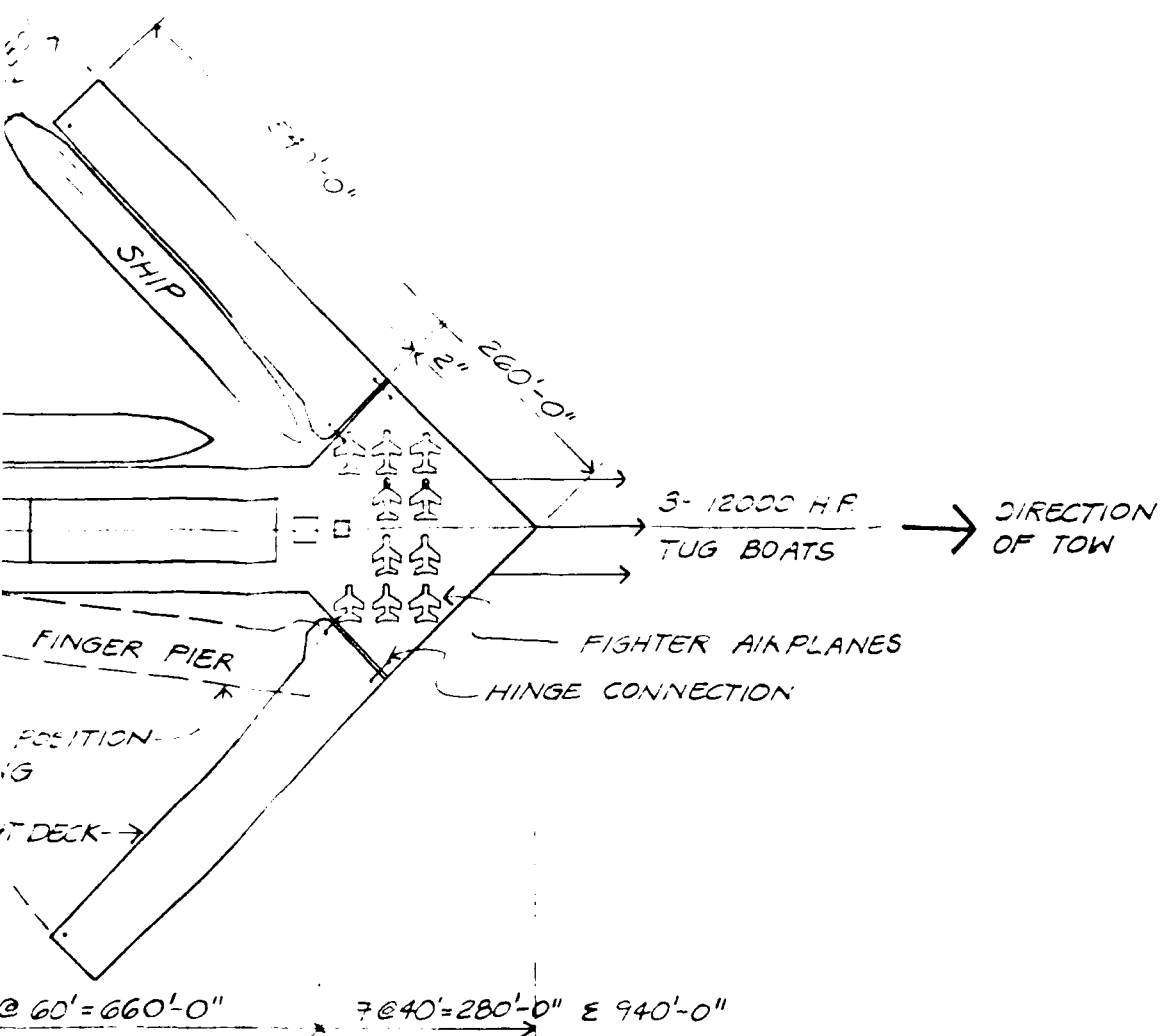
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Issued For

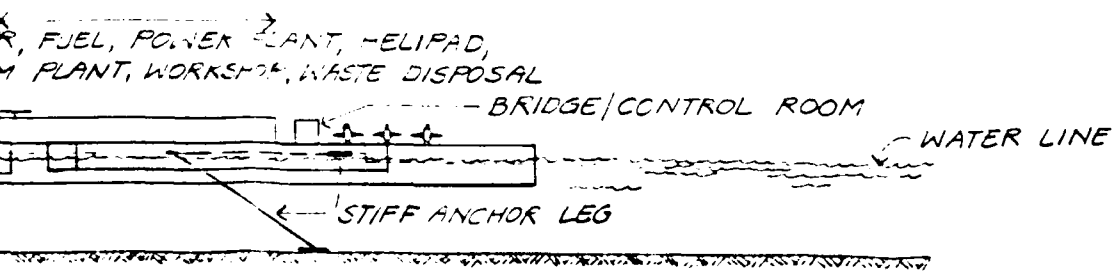
100%

Date

Dec 1, 8



# PLAN



# PROFILE

1" = 200'

Nº	REVISION	DATE
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Issued For	Date	By
100%	DEC, 82	KM

SHEET TITLE	SCHEME D
PROJECT	EXPEDITIONARY PIER

SHEET Nº	13
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END

DATE  
FILMED

9 - 83

DTI